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December 1938

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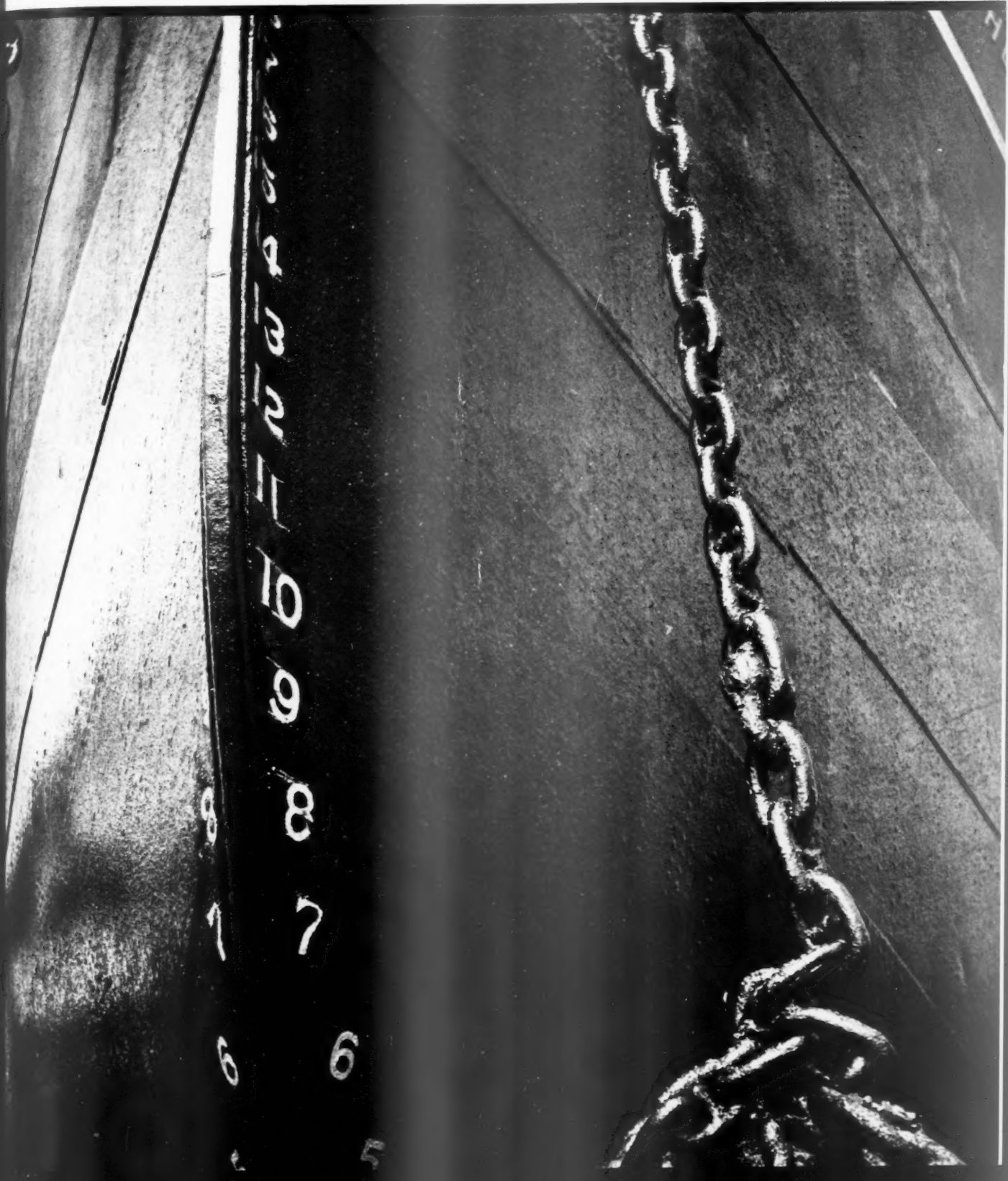

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THE TABULAR VIEW

AS this issue goes into the mail, the Editors are sending to a geographical cross section of Review readers a questionnaire entitled, "What is the Matter with Our Houses?" Even if one does not answer the questionnaire (we hope you will), the document is stimulating and provocative, and we think you would like to have a copy. So if you do not receive one of these probes and have some pet gripes and strong feelings on home ownership, housing cost and construction, the problem of the back porch, and the removal of fingerprints and spitballs from Junior's wallpaper, drop a card to The Review, and a questionnaire will be sent to you with enthusiastic promptness. The document is designed to elicit information not from specialists but from the layman, whoever he is. (As some wag has paraphrased Gelett Burgess, '87: "I've never seen a layman, I never hope to see one. But this I know that anyhow, I'd rather see than be one.")

AMERICA has pioneered in air transportation since the Wrights first flew at Kitty Hawk. Take for example the high-altitude investigations described by S. PAUL JOHNSTON, '21, on page 71. It might be added as a footnote to Mr. Johnston's article, as Professor John R. Markham, '18, has pointed out to us, that the Boeing Company is building a "Stratoliner." The Curtiss Company has arranged the fuselage structure of a transport that they are building so that its cabin may be put under pressure if they decide to operate at high altitude later on. The Martin Company in Baltimore built an experimental fuselage on which they conducted a number of tests under pressure. The Douglas Aircraft Company has made a very thorough study of the problems involved in the trend toward flight at higher altitudes. There have been a number of publications on this subject, and at the last meeting of the Institute of the Aeronautical Sciences a section was devoted to the reading and discussion of these problems. A concise and thorough summary of the problems is given in an article by W. B. Klemperer in the *Journal of the Aeronautical Sciences* of March, along with other papers on the subject. Mr. Johnston is editor of *Aviation*. ¶ So far as we have been able to discover, the article on page 74 is the first popularized article that has been written on the important technique of powder metallurgy and there have been few scientific papers. JOHN WULFF, the author of The Review's pioneer presentation, is associate professor of physical metallurgy at the Institute, and at the present time he is conducting a seminar on the subject. ¶ KARL T. COMPTON is president of the Institute, and his article on page 77 of this issue is drawn from an address by him before the International Management Congress this fall in Washington. ¶ NORBERT WIENER (page 66) is professor of mathematics at the Institute and a frequent contributor to The Review. ¶ TENNEY L. DAVIS, '13 (page 80), is an editorial associate of The Review and professor of organic chemistry at Technology.

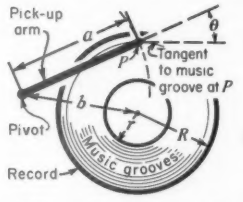
No. 11

Just for Fun!

A CHALLENGE

TO YOUR INGENUITY

RECENTLY, much attention has been given to the "tracking" of phonograph pick-ups on disc records. Formula (1), below, is easy to derive, but can you verify formula (2)?



In the range $R-r$:

(1) To keep the largest absolute value of θ as small as possible, let $a=\sqrt{b^2-Rr}$

(2) To keep the *change* in θ as small as possible, let $a=\sqrt{b^2+Rr}$

These formulae may be well known, but we have not seen them elsewhere. They, and many others, were worked out in 1926 to solve this and related phonograph problems.

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MAIL RETURNS

List All Papers Published?

FROM LEICESTER F. HAMILTON, '14:

In looking over the President's Report, under date of October, 1937, and The Review for last month, it occurred to me that it would be advisable to ask the Editors of The Review to consider the following suggestion. I have talked this matter over with some of the members of our Department [Chemistry], and they concur.

The President's Report for October, 1937, gives space to a list of publications by the Institute staff — publications which are numbered consecutively and are credited to the various Departments of the Institute. This is a logical procedure and should be continued. I feel, however, that you might consider the advisability of allotting a certain amount of space each month to the publication of the titles and authors of such scientific articles as are printed as the result of the efforts of the staff. This suggestion is based on the belief that the graduates of the Institute are interested in scientific developments, and while they may be members of one scientific society and receive the journals, they are not necessarily members of all scientific societies; therefore, notice of the publication of many of the articles does not come to their attention. I realize The Review is an alumni journal and as such should be devoted to alumni affairs, but our Alumni are naturally interested in the Institute and its staff, and we should, perhaps, stimulate their interest by affording them the opportunity to know what the staff, or the Institute, is doing along scientific lines.

My suggestion is that a system be evolved whereby the Departments notify you each month of the appearance of these articles in the various scientific journals.

In the President's Report for October, 1937, 340 such articles were listed. On this basis, space will probably be required for about 40 titles in each issue of The Review.

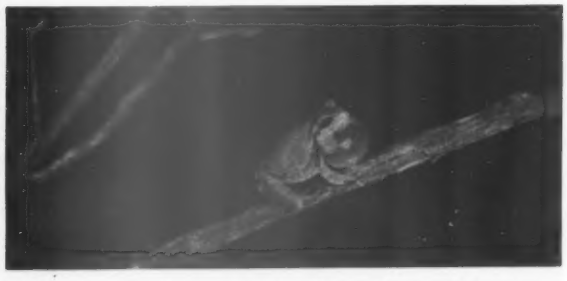
I shall be pleased to assist in any way, if this suggestion is adopted by The Review.

M.I.T., Cambridge, Mass.

The Review is impressed by Professor Hamilton's proposal, will act upon it if Review readers agree. Would you welcome a monthly list of staff papers to supplement the list of alumni papers already published?

Wild Life at Night

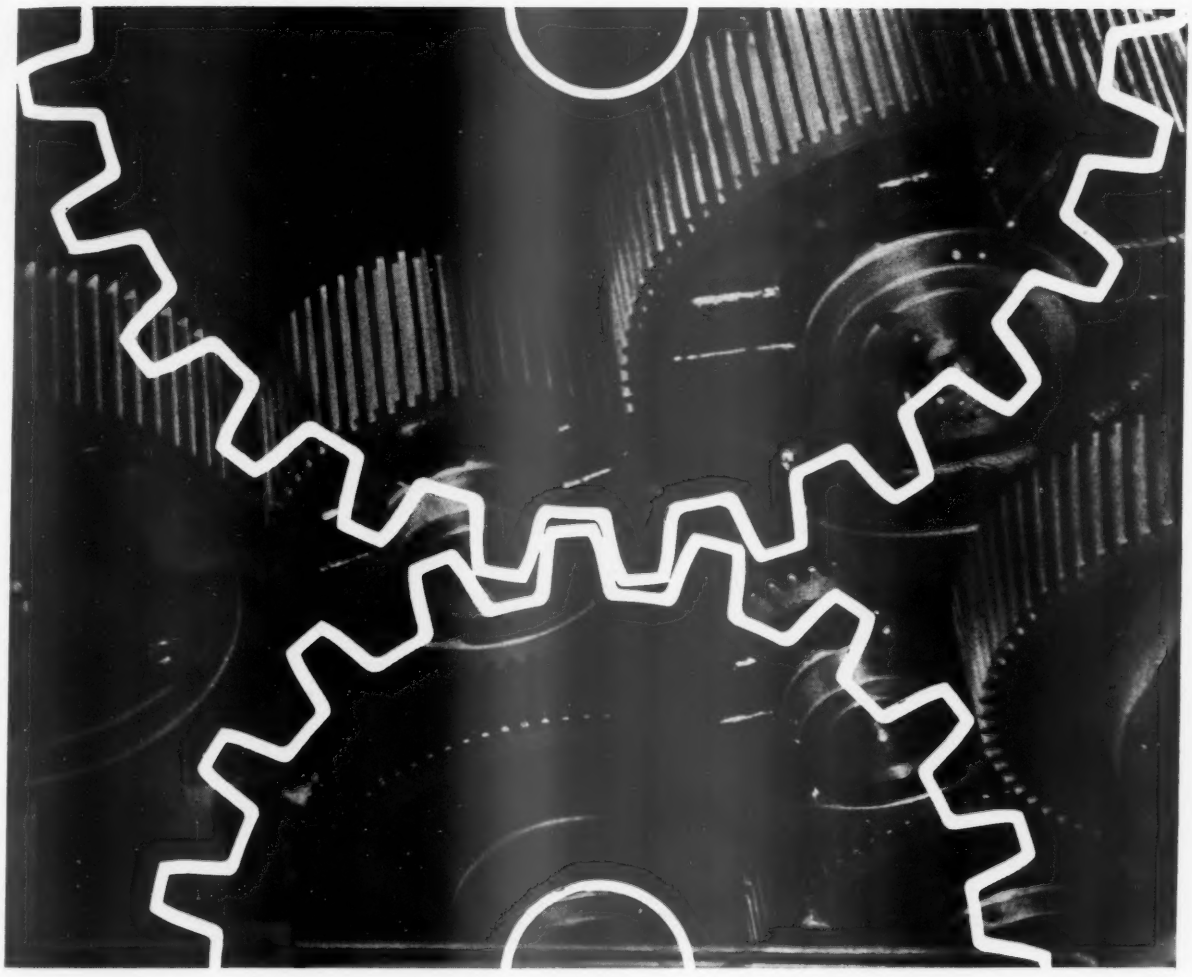
FROM HOWARD CLEAVES:



New Jersey male tree frog in full song in natural location. Enlarged from 35-millimeter motion picture frame. Taken about 9:30 p.m. Illumination supplied by portable generator outfit

. . . I wonder if you have heard of the work I am doing in making motion pictures of wild-life subjects in wilderness places *at night*. So far as I can learn this is a distinct technological advance in the making of motion pictures. Heretofore only still photographs by flashlight (mostly through the use of magnesium powder) have been taken by wild-life photographers. Apparently not even Martin Johnson ever thought of the method I am using, because if he had he certainly would have applied it in Africa. Think what he could have done around those water holes at night. . . . I inclose a glossy print which you are at liberty to publish. . . .

Staten Island, N. Y.



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The Goodyear COMPASS Cord is a modernized flat belt version of the ancient rope drive. With rope drives, as you know, it is necessary to use grooved pulleys to keep the ropes from running off due to their torque or twisting action.

In the COMPASS this torque is balanced by twisting the ropes, or cords, on opposing sides of the belt axis in opposite directions. Alternate warp threads in the fabric cover are similarly twisted. This patented construction in both body and cover neutralizes any tendency to run off the pulley with an equal pull toward the opposite side, insuring a belt that runs true.

More than this, it permits Goodyear to use larger, stronger cord, eliminating fabric plies entirely in the carcass, and making a thinner, stronger belt with far higher flex-life and longer service-life.

The best proof of this is the remarkable performance of COMPASS belts on industry's hardest drives. From two to five times longer life with practically no stretch is typical. So don't be deceived by the word "cord." The Goodyear COMPASS Cord belt is the only belt in the world with patented balanced cord construction that insures true-running, high flex-life, low stretch and maximum wear. To test COMPASS superiority for yourself, call the nearest Goodyear Mechanical Rubber Goods Distributor.

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The Reclamation Era

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THE TECHNOLOGY REVIEW

Title Reg. U. S. Pat. Office

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOL. 41, NO. 2 CONTENTS DECEMBER, 1938

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IN DRY DOCK
From a photograph by James N. Doolittle

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James N. Doolittle

Sunlit Glade in Technological Jungle

The complexity that is Hollywood silhouetted against the simplicity that is its product

THE
TECHNOLOGY
REVIEW

Vol. 41, No. 2

December, 1938

The Trend of Affairs

Hello!

WE said a "hello" and a "What hath God wrought!" over one of the new telephones the other day, and it required a bit of subsequent investigation to find out why the instrument seemed to "talk" differently. The answer is that you no longer hear your own voice muttering in your own receiver as loudly as in the old instruments. "Anti-sidetone" it's called, and the phone is sleekly and pawkily contrived to reduce the sound level reproduced in your receiver from what you are saying into your own transmitter. This not only reduces the level of extraneous room noises (sidetones) in your receiver but induces you subconsciously to speak a little louder for the benefit of your listener.

The new combined set has its own bell in the base of the instrument and a plastic molded handset of new and economical design with quickly removable transmitter and receiver units. Working through the improved anti-sidetone circuit, these instruments give greatly improved transmission performance. They are also less susceptible to noise caused by power transmission systems on certain types of party lines.

The new instruments also have much quieter dials, a fact which the telephone user will overlook unless he has the opportunity to make a direct comparison. Incidentally, dials used by telephone operators in private branch exchanges operate much faster than those on the instruments of the subscribers. The operator one reaches by dialing O on a city exchange often completes calls by pushing buttons on a keyboard like that of an adding machine. These methods make possible the quick completion of calls.

There are other new tricks in dialing: To the already astonishing capabilities of the automatic machine switchboards, many of which are now being equipped with a new and economical type of switch called the crossbar switch, has been added a new switching operation. Known in telephone parlance as "toll diversion," this system makes it possible to limit the use of dial telephones to calls having certain prescribed areas. By this method one may, for example, dial any five-cent call within the local exchange district, but should one try to dial a toll call or any call costing over five cents, the toll diversion system will automatically switch the call to an operator. This feature is particularly valuable in large private branch exchanges in industry and business for keeping an accurate record of long-distance calls. It effectively prevents unauthorized use of the telephone.

A development upon which telephone engineers are now working holds the promise of direct dialing of long-distance calls. By this method each city would have a dial code in letters or numbers similar to exchange names. Having dialed the code for the city, the subscriber would then follow with the local exchange code and telephone number of the person he wished to reach in that city. This system is already in use in some European countries.

New types of carrier-wave systems for ordinary cable and wire circuits have increased the capacity of these channels. It is now possible to carry 12 conversation channels on each pair in an ordinary telephone cable and 16 channels on existing open-wire pairs. This development greatly increases the capacity of present facilities and probably will make extensive expansion of wire and cable circuits unnecessary for some time in the future.

Although there are now only about 15 cities in this country which have enough telephone traffic of a nature to justify its use under present conditions, the coaxial cable — a copper tube with a concentric wire inside — has an amazing capacity for the transmission of con-

versations. Over a pair of such cables it is possible to transmit simultaneously 240, 360, or 480 separate conversations, the number depending upon the spacing of repeater stations. The shorter the spacing, the greater the channel. Aside from its possibilities for telephone communication, the coaxial cable holds great promise for carrying television signals.

England has the largest system of coaxial cables, four of which link London, Liverpool, Manchester, Leeds, and Newcastle. One pair is used for telephone circuits, while the other is employed exclusively for transmission of television programs. The only installation in this country is the coaxial cable between New York and Philadelphia.

There are — if you have a statistical tooth — over 37,000,000 telephones in service throughout the world, of which some 19,600,000 are in the United States. Of this number approximately 8,000,000 are dial instruments operating through automatic machine switchboards.

Aesculapius to Mercury

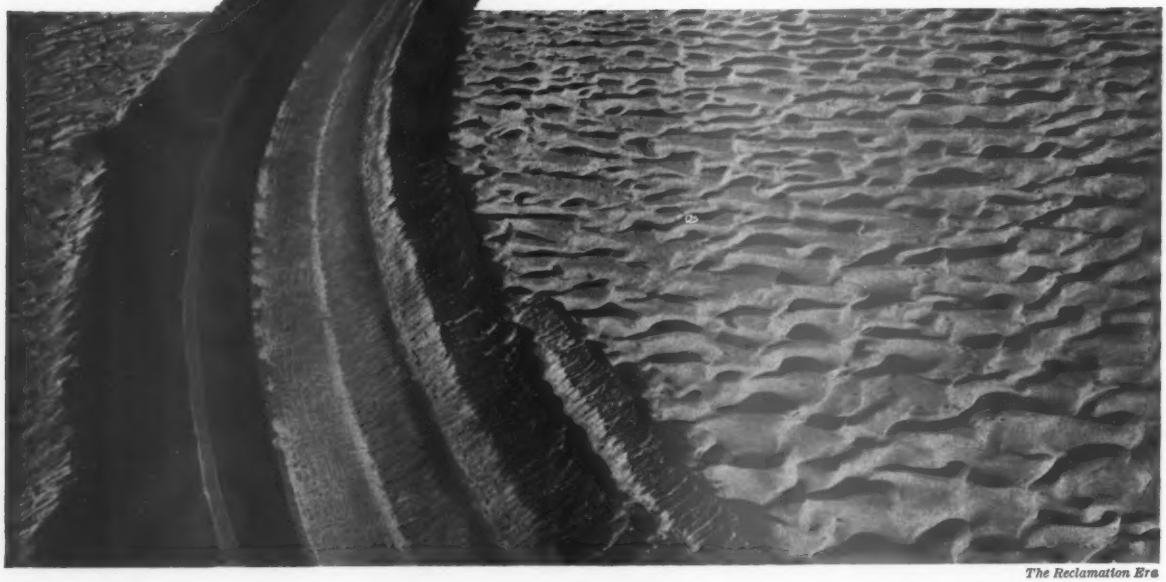
AMONG the most delicate and difficult of the activities of publishing the news is that of presenting in understandable and accurate form reports of scientific developments. Problems of terminology alone would suffice to place this kind of writing among the most exacting; but these problems are augmented by the puzzle of how to explain the intricately technical to the untrained lay mind, by the constant hazard that the lay mind will draw utterly unwarranted analogies with what is written, and by the frequent peril involved in the fact that, in science especially, a little knowledge is dangerous.

In no aspect of its relation with science is the work of writing and publishing more subject to these troubles than in the task of reporting matters having to do with public health and medicine. Here, more than in any other field, the danger of misinterpretation, of unjustified encouragement, and occasionally of rash application is increased in its seriousness by the fact that the question of life and death is concerned. Dread of disease easily leads the uninstructed reader to see in even a most cautiously worded story basis for hope which in reality does not exist. The moral responsibility of the writer to both the scientist whose work must not be prejudiced and the reader whose natural human impulses must not be misled is a decidedly heavy one.

Award of the Clement Cleveland Medal "for outstanding work in the campaign to control cancer" to the National Association of Science Writers is therefore an event of considerable import. The association, but five years in existence, consists of newspapermen who specialize in the presentation of scientific and technical news. The standards of performance which it has set and which have thus been signalized — involving as they do a still more exacting interpretation of the old-time journalistic requirement of accuracy — promise well for the future relations of science and the press. That these relations will continue to increase in importance is assured both by the growing volume of scientific news and by this evidence of greater confidence which the men of science are

THROUGH DESERT SANDS

. . . The great man-made river known as the All-American Canal executes this impressive sweep. The canal will carry water diverted from the Colorado River to the great Imperial Valley in the southern part of the Salton Sink, where once was ocean. The lowest portion of this enormously fertile basin is 287 feet below sea level, 300 feet below the bed of the Colorado



The Reclamation Era

coming to place in the men of the written word. Such increased coöperation of the two groups as is foretold in this award must in the end be of inestimable benefit to men in general, particularly in fields such as the control of cancer, where forewarning and consequent early attack on disease may add years to the individual life.

The Spice Trade

ROSEMARY and onions lend atmosphere, voyages by Columbus and microscopes by Bausch and Lomb merge with a distinctly tropical flora for background, pickles, perfumes, and pharmaceuticals yield variety, while canned goods and cattle feed give substance to this survey of the spice trade as of the third decade, 20th Century.

In volume and value, today's trade in spices and related products is insignificant when compared with the huge quantities of minerals and manufactured goods which flow between continents. Were it not for the rise of the synthetic essential oils, the technical advances in this field would not merit a paragraph in an engineering history of our times. But cinnamon and nutmeg can add zest even to a bare statistic, and it is hard to forget that merchants once lined the routes to the spice lands with their bones, that governments fought for aromatic territory, and that the Western Hemisphere is more or less a by-product of the search for the fabulous Indies.

George A. Grant-Science Service

SAND DUNES AT SUNSET

Three hundred feet below sea level, sand on the floor of Death Valley drifts into weirdly beautiful patterns

Although their properties as preservatives are no longer vital, their ability to give flavor and piquancy to beverages and foodstuffs still makes spices indispensable. Manufacturers in this country are today using about half a hundred varieties of fruits, seeds, roots, flowers, and herbs, each of which — through some fortuitous metabolic accident — produces an essential oil, or a group of such oils, which is capable of giving the human palate a thrill — a thrill frequently that is without counterpart in the laboratory.

These essential oils, however, are chemicals which often have properties other than flavor or aroma. The bulk of them have some medical qualities; many (as is to be expected because of the close connection between taste and smell) are used in perfumes; and a few have industrial significance. According to a recent tabulation in *Food Industries*, pharmaceuticals use a larger variety of spices than does any other outlet — the ones mentioned as not yet exploited in this field being sesame seed, tarragon, poppy seed, parsley, curry powder, and cayenne. New vistas, apparently, still stretch before the druggist. As might be expected, meats, soups, and canned goods rate high in the number of spices they may contain, but it seems surprising that cows absorb such exotic products as ginger, cayenne, anise, and fenugreek, and that one brand of cigarette (not a major one) features in its advertising the fact that it is the only unflavored cigarette sold in this country. Among the flavors which the others may contain are cloves, cayenne, mace, and paprika. Four widely used spices — nutmeg, pepper, cassia, and cloves — take part in the manufacture of insecticides. To intensify the industrial note, some tanning preparations contain paprika, saffron, and turmeric. Nor can the family of essential oils deny their relationship to that black sheep, turpentine.

Even this ancient field is not immune to the meddling of technicians. Whenever the flavor of a spice is caused almost entirely by one chemical substance instead of a large number of related molecules, that plant product is frequently replaced by a synthetic counterpart made under controlled conditions and in known concentration. Methyl salicylate tastes and smells like — in fact, is — oil of wintergreen; mustard oil finds competition with allyl isothiocyanate difficult; and the most widely used synthetic flavor, vanillin, closely resembles the aroma of the vanilla bean, the fruit of a climbing orchid native to the land which frustrated Columbus' attempt to reach Cathay.

The flavor of the vanilla bean, of which the world uses six hundred thousand tons annually, is generally applied in the form of an alcohol extract. With this successful technique in mind, several spice handlers have been attempting during the past seven years to furnish every important flavoring and seasoning mate-

RCA Manufacturing Company, Inc.

HERE ARE RADIO TUBES IN THE MAKING

The visual overtones of an industry spectacular in its processes as in its growth

rial in a similar concentrated and standardized form. For better or worse, American manufacturers like to have every can like every other can, and they shudder at French recipes which call for a *suspicion* of garlic or for a *sprinkling* of pepper. In response to this demand for uniformity, the spice handlers are rapidly succeeding in neutralizing the effects of geography, climate, soils, and microörganisms by extracting the spice essences and grading their flavor intensity against arbitrary standards.

Attempts at steam distillation of ground spices resulted in concentrates which represented only part of the flavor; solvent extraction has been found to produce superior results, which fact in turn has posed problems relating to choice of solvent, evaporation techniques, and methods of handling the frequently sticky and viscous residues. These residues are generally diluted to known concentrations in edible carriers like salt or corn sugar.

Because the essential oils are volatile to varying degrees, disinfecting by steam or heat is as difficult as is extraction. And contrary to what one would expect from their preserving and medical properties, spices sometimes carry very large numbers of microbes. Present practice tends toward the use of such fumigates as ethylene oxide and formaldehyde.

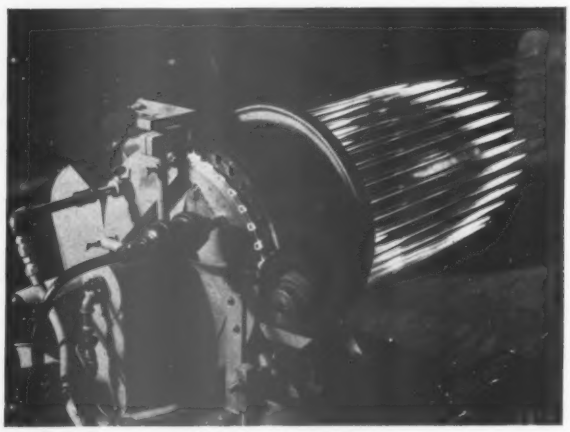
Even with bacterial counts and solvent recovery systems, however, the spice trade as practiced by the 200 members of the American Spice Trade Association would probably still appear quite recognizable to the Chinese officials who long ago were forced to hold cloves in their mouths while addressing their emperor (and some advertising man got paid for that idea!).

"Science for the Citizen"

BY NORBERT WIENER

THE present age is seeing a recrudescence of encyclopedism. The 18th Century still believed that the whole of science could be put into universally approved and universally read compendiums, but, then, the 18th Century was still an age in which the brain of a man like Leibnitz could in itself be one of these compendiums. In the 19th Century the content of science outstripped the power of any one man to grasp it both as a whole and in all its details, and the scientist deteriorated from a sage to a specialist. In this, our 20th Century, the technique of specialization has so developed at the cost of a broad grasp of learning that we are turning to encyclopedism not as the natural point of view of a man with any claims to consider himself learned but as a desperate struggle against scientific provincialism, one-sidedness, and ignorance, and as our only hope in our attempt to make science attain its proper social conscience and social maturity. In this important task we owe much to the tradition of literary articulateness of English science and to the breadth of vision of such men as H. G. Wells, Julian Huxley, and now Lancelot Hogben.

The encyclopedists of today face a far more difficult task than did their ancestors in knee breeches and tie-wigs. It was physically possible and not mentally impossible for a scholar of those days to have read everything of importance that the learned world had produced. Nowadays the physical impossibility is as great as the mental. Not only are there no universal scholars but there are no universal mathematicians, and indeed no universal analysts or algebraists or other specialists within specialists. Thus in a book like Mr. Hogben's "Science for the



Citizen,"* it is far more just to praise the many aspects in which his adventure into universality has been successful than to cavil at those defects which inevitably result from his having only the reading and scholarship of one lifetime at his disposal.

Mr. Hogben's book is entitled, "Science for the Citizen." There are many views possible as to who the citizen is and what are his merits and demerits. No democracy is possible unless the citizen is an individual whom we can treat with respect and to whom we can attribute a due degree of maturity. Mr. Hogben's citizen must be a man who is prepared to think hard and read carefully. Yet he need not in any way be a man whose formal training amounts to more than he can acquire in a good high school or than he can study up for himself if his opportunities have been restricted.

Nevertheless, if he is to get anything like full value out of the more than 1,000 pages which Mr. Hogben has put before us, he must be prepared to work hard. He must be prepared to learn the main facts of astronomy, mechanics, chemistry, heat engineering, the theory of electricity, biology, agricultural science, medicine, and psychology. He must be prepared to think through all these subjects not merely as isolated fields of learning but as matters of vital social significance. A man who can do this and is willing to do this, whatever his formal training, is an educated man. I thank Mr. Hogben for a salute to the intelligence of the community. I thank him for reinforcing the easy flow of his style by examples for the reader to work and to test his own understanding. It is only by the aid of such books that we can hope to build men fit to live in this age of science and to take responsibility for its employment.

But as I have hinted before, a book of this scope will have its weak places; and a man, however able and enlightened he is, will have his pet hobbies. Mr. Hogben has a biting contempt (which I share) for the astronomical theologian and a further biting contempt (which I do not altogether share) for the pursuit of Classical learning. It is easily understandable that the mandarin training of the English youth destined for the employment of his country should excite the indignation of one who sees only too well the harm which this anachronistic point of view has brought to his country and the world. Nevertheless I greatly miss in our own young men the sense of history and the sense of belonging to a world which transcends our own epoch and land, which I find among men with a good Classical training.

With all due respect for the pragmatic and social motive which Mr. Hogben stresses so much in the history of science, I find that he has not done adequate justice even from this side to the theoreticians and philosophers of science. His hatred of Aristotle is understandable enough in view of the paralyzing effect of Aristotelianism on the scientific progress of centuries. But I think this hatred is unduly transferred against the position of Aristotle in his own time and environment. Leibnitz comes in for very little comment, although a most interesting story could be made of the relation of Leibnitz' monadology to the spermatist biology of his times. The names of Heaviside and Gibbs are not even mentioned, though their theoretical work

*New York: Knopf, 1938. 1,082 and 19 pages. $5.00.

For Tomorrow's Newspaper — a photograph by F. S. Lincoln, '22

is in the most intimate relation to the technical progress of electrical engineering and physics. On the other side it is manifest that while Mr. Hogben knows biology and biological statistics as intimate friends, his interviewer's acquaintance with the various fields of engineering has been largely made for the special purpose of writing this treatise. I do not find an adequate study of the way in which engineering development has been limited by the materials at its disposal, of the way in which it has invented its own materials, of the way in which tools are the products of tools; nor do I find anything like the detailed study of individual engineering inventions which would well fit into the frame of the book.

To sum up: Mr. Hogben has written a courageous, intelligent, and powerful summary of modern science as it appears from the point of view of one single man who, however courageous, intelligent, and powerful of intellect he may be, is yet obliged to look at fields of work oblique to his own with a considerable parallax.

Ultimate Cold

A GELID world in the region of absolute zero, where heat vanishes, molecular motion all but stops, and the behavior of matter takes strange new forms, was described by Dr. Frederick G. Keyes, Head of the Institute's Department of Chemistry, in a lecture of extraordinary importance at the November meeting of the Northeastern section of the American Chemical Society on November 11.

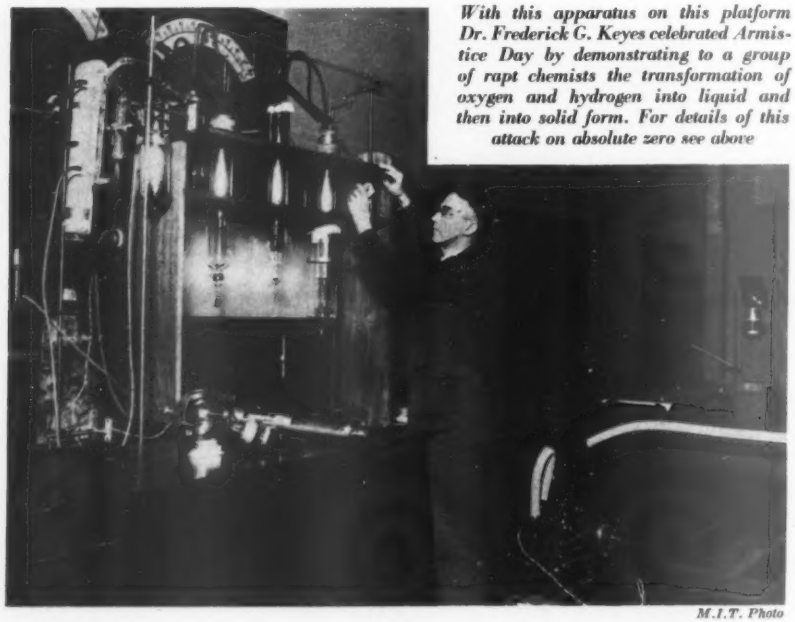
Dr. Keyes's subject was "Low Temperature Research and Its Significance," a field in which he is internationally known as an authority. His audience watched with intense interest when he demonstrated, for the first time at the lecture table, the transformation of oxygen and hydrogen gases first into the liquid form and then into the solid state. This new technique, developed by Dr. Keyes, is one of the most important advances in its field for many years and makes possible the liquefaction of gases, including helium, without the aid of expensive and heavy compressing machinery. The earlier techniques involved the use of glass and put a severe limitation on the scope of possible experimentation. The new technique employs metal apparatus, eliminating the use of glass entirely, and thus places low-temperature research on an engineering basis.

As a simple and economical technique for experimentation at temperatures in the region of absolute zero, which corresponds to 459.69 degrees below zero F., Dr. Keyes's method opens the way to new frontiers for research in the region of ultimate cold. It requires but a third to a quarter of the amount of refrigeration used in older systems, and it is safer to operate. The glass apparatus with which Dr. Keyes carried out his experiments was a model of larger metal equipment which has been developed in the Institute's cryogenic research laboratories. He demonstrated the astonishing increase in the tensile strength of copper at a temperature of 320 degrees below zero F. and also showed the enormous fall in electrical resistance at low temperatures.

Reviewing the history of attempts to liquefy the permanent gases with the objective of attaining absolute zero, Dr. Keyes said: "The object of scientific research in the broad sense is an increasing comprehension of the properties of matter. At the extremes of the temperature scale the complexity of natural phenomena is in many respects simplified. Thus the properties of all known living tissue are either suspended or terminated at low temperatures and completely destroyed at high temperatures. With inanimate nature the chemical combinations which are stable diminish rapidly at elevated temperatures, and finally at the temperatures of the hottest stars there exists only hydrogen or helium. At low temperatures, however, striking variants of the ordinary temperature behavior of matter have become evident. Thus the heat capacity of solids gradually diminishes, then drops rapidly to become sensibly zero at a few degrees.

"At lower temperatures the electrical resistance falls until, in the case of some metals, a temperature point is reached where an abrupt drop to zero resistance occurs. Examples are lead at 7.25 degrees C., mercury at 4.12 degrees, and zinc at 0.79 degrees. But this is not all, for on applying a magnetic field the resistance is restored with attendant effects which made evident the lack of generality in our modern electrical theory based on Faraday's experimental work of the last century.

"In time, as electrical phenomena at low temperatures are more clearly understood, a profound modification of the existing theoretical structure will undoubtedly be effected with attendant practical results which may be of



With this apparatus on this platform Dr. Frederick G. Keyes celebrated Armistice Day by demonstrating to a group of rapt chemists the transformation of oxygen and hydrogen into liquid and then into solid form. For details of this attack on absolute zero see above

M.I.T. Photo

President's Palace, Panama City — F. S. Lincoln, '22

Cygnets — Lewis P. Tabor, '22

Our pictorial aviary this month is devoted to exhibits of the exotic and graceful

outstanding significance. At present, for example, it is not practical, because of transmission-line losses, to send power more than several hundred miles from a generating station. This is one of the reasons which make the politician's passion for squandering tax money on high-power developments in remote places so irrational. It is conceivable, however, that scientific research on electrical phenomena at low temperatures, which has already indicated that a condition of zero electrical resistance exists, may lead to the development of the means of transporting the power economically for long distances and thereby salvage something from what otherwise appears pitiful waste.

"The properties of numerous metallic alloys have become known in the past 15 years and have made possible developments in all branches of applied science which would have been believed impossible even 20 years ago. The investigation of alloy properties at low temperatures, both electrical and mechanical, has already disclosed interesting possibilities, but scarcely more than a start has been made in the study. The chief value of these researches will lie, however, in the insight that will be developed into the at present bewildering complexity of the phenomena exhibited by alloys. A whole new world of intellectual and practical interest lies before us.

"The conduction of heat in liquids, solids, and gases manifests variations from the ordinary temperature behavior which are most curious. As an example, liquid helium at 2.19 degrees C. undergoes a change in properties. Above this temperature the liquid exhibits the properties we are accustomed to regard as typical. Below this temperature, however, the liquid becomes at least 800 times a better heat conductor than copper at ordinary temperature. The fluidity also augments so much that a vessel which was tight to helium above 2.19 degrees C. may be pervious below this temperature. The heat conductivity of pure copper increases several-fold on cooling to hydrogen temperatures. Some salts have been investigated and show a minimum of conductivity at very low temperatures. Heat conductivities are, however, difficult to measure, and good procedures adapted to low temperatures have yet to be developed. Because of the relation which current theory establishes between electrical conductivity and heat conductivity, the whole subject is of tremendous importance. What is of scientific importance becomes ultimately, of course, of extending practical importance.

"A field wholly neglected at present is the measurement of mechanical properties at low temperatures, although Dewar started the work and a few new attempts have been recorded lately. What we need are accurate measurements of the temperature dilation, ultimate strength, yield-point characteristics — first for pure metals and then for alloys.

"During the past 20 years the use of x-rays has revealed the structure of crystals or the space arrangement of the atoms in solid matter generally. At low temperatures the vibratory motion of the constituent atoms dies down, and in the case of certain salts called paramagnetic interesting knowledge about the crystal forces becomes possible by utilizing the facts obtained from a knowledge of the magnetic properties combined with those pertaining to the heat capacity and x-ray structure. A knowledge of these crystal forces makes possible the calculation of important crystal properties at ordinary temperatures where applications are already of practical significance in the few cases where empirical knowledge has been available in special instances."

Facilities for low-temperature research at the Institute include the most powerful existing magnets, which were designed and built by Dr. Francis Bitter of the Department of Metallurgy. (See The Review for January, 1937, page 116.) The possibilities of these magnets were indicated when Dr. Keyes disclosed that they will enable investigations of matter at the lowest temperatures thus far attainable, namely 0.001 degrees absolute, which is within a fraction (*Continued on page 101*)

Aerial Photography—from a photomontage by F. S. Lincoln, '28

U. S. Army Air Corps

THE COLLIER TROPHY

. . . which this year was awarded to the United States Air Corps "for having designed, constructed, and completely equipped the XC-35 substratosphere plane, the first pressure cabin airplane to be flown successfully anywhere in the world." For a picture of the XC-35, *see page 73*

Higher Highways for Tomorrow

Carrying Sea-Level Comfort Above the Clouds

By S. Paul Johnston

THE STORY BEHIND THE AWARD OF THE COLLIER AVIATION TROPHY — STRETCHING THE RANGE OF VERTICAL TRAVEL — DIVING AND "UNDIVING" SUITS — STRANGE AND UNEXPECTED TROUBLES ENCOUNTERED

WE humans like to think that we are fairly rugged animals, but actually our bodies are very delicately balanced mechanisms that require rather carefully controlled surroundings in order to support the spark of life in them. If it were not for the fact that we have discovered artificial means (such as clothing and heated buildings) for keeping body temperatures constant, we should be limited in our travels over the earth's surface to the narrow confines of the quite temperate zones. Also, if it were not for physical artificial means of keeping the pressure and the chemical make-up of the air surrounding our bodies fairly constant, we would be limited in our vertical travels to a very thin shell of atmosphere, in thickness less than one-tenth of one per cent of the radius of the earth.

Although, to most people, that 15,000 feet of usable air space vertically may seem to afford ample room in which to move about without undue crowding, some of us have become a bit restless under such a restriction. Perhaps it is just that perversity of human nature which sees in natural barriers only a challenge to pass through them. More practically, from the standpoint of aviation, it seems probable that we can fly farther, faster, more comfortably, and more economically in the less dense upper reaches of our atmosphere, provided we can get there and provided that we can stay there for a while once we have arrived.

The work of D. W. (Tommy) Tomlinson of Transcontinental and Western Air, Inc., which began in the fall of 1934, marked a new beginning in scientific endeavor to make the substratosphere a passable, tolerable highway. His objectives were: (1) to develop means of supercharging an aircraft engine to develop its rated power up to 30,000 feet; (2) to determine the increase in speed possible for a given airplane with increased altitude at constant power; and (3) to make studies of weather conditions at the base of the stratosphere. The results of his test flights (reported before the Institute of the Aeronautical Sciences in December, 1937, and more recently before Germany's Lilienthal Gesellschaft this past October) provide the base on which will stand all subsequent high-altitude research with airplanes.

From Tomlinson's work, however, it became apparent that to develop machines capable of climbing to, and flying at, substratospheric levels was easier than to keep their pilots and their passengers alive and well in those rarefied regions. It became increasingly obvious that something more than an occasional whiff of oxygen was needed to maintain normal bodily activities. Serious and alarming symptoms took place, which were traceable not only to oxygen deprivation but also to continued exposures to reduced atmospheric pressures as well as rapid changes from one pressure level to another. Anyone who has ever been subjected to descent in an

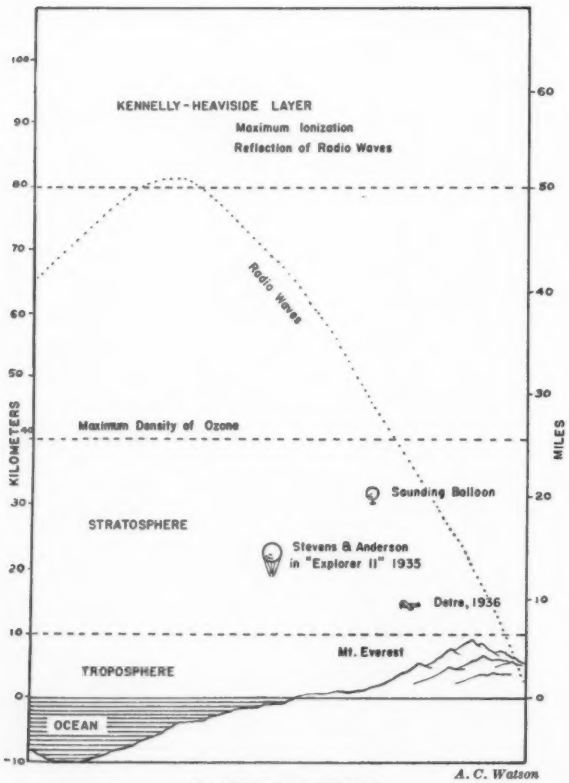
airplane from, say, 12,000 feet to sea level, while enjoying a slight cold in the head, can easily appreciate the problem. Deep-sea divers and sand hogs working in caissons have the same troubles in reverse. Not that such phenomena are strictly new. An extensive medical literature has already been built up on the subject. Some years ago Wiley Post and some of his predecessors, in shooting for really high altitude marks (50,000 feet or better), built themselves airtight suits and helmets along the pattern used by deep-sea divers. Inside these clumsy and grotesque garments they were able to maintain reasonably normal oxygen and pressure conditions under a wide range of outside variations.

That was a fine idea as far as it went, but imagine asking airline passengers to climb into a combination armor and diving suit and connect themselves up with a sort of central plumbing system just to save an hour and a half's time between New York and Chicago! Not a bit of it! The modern air traveler knows that he is entitled to club-car luxuries and freedom, to a cigarette when he wants it, and to well-served meals aloft, none of which he could have when encased in a shell of rubber and armor plate.

Clearly, that means only one thing. The entire passenger portion of the substratosphere airplane of the future must be built as a pressure-tight tank within which conditions of atmosphere and pressure may be kept at, or near, sea-level conditions at all times. Passengers must be able to move about and to carry on their normal traveling activities inside the pressure cabin as readily as they might if they were ashore. And that is exactly what aeronautical engineers and aircraft builders are planning to do. It was for sponsoring the first practical work in that direction that the Army Air Corps was awarded the Collier Trophy this year.

Flight

FROM PRESSURE SUITS . . .



A. C. Watson

ABOVE OUR HEADS

Pertinent to the adjacent story is the above diagram of the atmosphere and of man's relatively puny efforts to penetrate it. The pressure-cabin experiments were carried out between five and six miles up

Air Corps interest in high-level flying in pressure-sealed cockpits goes back a good many years. It was tried in a crude way just after the War when a boilerlike arrangement was installed in the fuselage of a DH-4. Lieutenant Harold Harris (now operations manager for Pan American Grace at Lima) set out for the substratosphere in the contraption, but presently returned to earth very nearly in a state of complete collapse. The "pressurizing" had worked, but too well. He had attained considerable altitude without difficulty, but on the descent the pressure relief mechanism had failed to function, and as he landed the air temperature inside his "tank" went to 150 degrees, with a pressure corresponding to 9,000 feet *below* sea level!

Other matters preëmpted Air Corps interest after Harris' uncomfortable experience, and the research was dropped for a time. Within the past few years, however, the advantages of high-altitude flying (both for military and commercial use) became so obvious that the project was taken down off the shelves, dusted off, and reëxamined. In the interim, Post and others had been experimenting with their "undiving" suits, and a couple of abortive efforts had been made abroad with tank-type cockpits in aircraft. But little of practical value had come out of any of this work, and the Army decided to start again from scratch.

Mainspring of the new movement was Major Carl Greene, an officer with a brilliant record for getting new things done. Ideas for a practical pressure-sealed airplane had been circulating about under the Greene helmet for a long time, and he found a sympathetic audience for them in Lieutenant Colonel Oliver P.

The Jules Vernish garb which enabled Squadron Leader F. R. D. Swain (left) *to live in the extremely rarefied atmosphere 49,967 feet above the earth has now evolved, happily,* (right) *into the substratosphere XC-35*

U. S. Army Air Corps

. . . TO PRESSURE PLANES

Echols, chief engineer at Wright Field, and in General Augustine W. Robins, who headed up the matériel division. The story was so good that presently the Army purse strings were loosened, and work really got under way. First move was to call in Dr. John E. Younger of the University of California to assist on structural problems. Greene and Younger had been teamed up before on the early work in developing *monocoque* wings and fuselages.

Like all good engineers, they were first concerned with setting up a clear-cut statement of the problem at hand. Starting with the premise that they could obtain a basically satisfactory airplane with engines capable of operating up to 30,000 feet, their preliminary work indicated that at least one satisfactory solution would have to be found for each of a list of 25 subproblems. These 25 broke down into four major groups: (a) structural features, (b) mechanical features, (c) air flow and its regulation, and (d) physiological requirements.

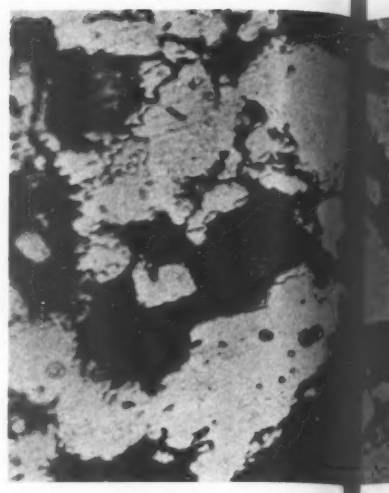
Short of designing and building an entirely new airplane, the shape, type, and size of the structure were more or less predetermined by the machine selected as the work horse. Its design factors had to be carefully overhauled, however, to make certain that it would hold together under the special loads to be imposed on it. Biggest job, perhaps, was to make the joints in the skin airtight under the pressures involved, as no inner skin, or tank, arrangement was contemplated. Then, too, no extensive expansion or bulging of the thin skin under pressure could be tolerated. The stress problem was unusually complicated throughout, as the normal flying stresses were augmented not only by the pressure stresses but by temperature stresses set up by rapid passage from warm sea-level temperatures to the below-zero conditions of the upper atmosphere. Some understandable concern was felt over the question of explosion of the structure in case of a sudden failure of a joint or through the development of cracks, a problem closely associated with the proper design of bulkheads and other internal structure. And something else to think about was how windows could be made large enough to see through properly and still stand the pressure.

Mechanical problems were as complicated as the structural. How to seal doors and emergency exits? More complicated, how to seal off the large number of small openings needed for the passage of moveable control wires and control rods to operate the control surfaces and all the gadgetry on the engines? How to remove, or to prevent, fogging and frosting of windows, both internal and external? It seemed desirable, also, to provide some sort of automatic window flaps to hold air pressure in case of accidental breakage of a pane of glass. It seemed to make sense, also, to consider means of utilizing the dynamic air pressure and the energy of the air discharged continuously from the cabin.

The air flow in the cabin and its regulation posed some unusual problems. Extremely light and extremely efficient compressor (supercharging) equipment had to be designed, fitted with highly sensitive and fully automatic regulation of quantity and pressure, free from noise (both aural and radioelectric), and entirely free from any danger of freezing up at altitude. Safety valves, both inward- and outward-opening, had to be provided. And in case of the failure of the supercharger, or of any of the parts of the system, means had to be found for the automatic sealing of the ventilating system and the release of an oxygen spray.

For the physiological factors, not much could be determined before making actual flight tests in the completed airplane. The list of problems to be solved, however, contained questions of how much air is required per hour per passenger, what pressure ranges might be tolerated, what rates of compression or discharge of air would be permissible in an emergency, and how to control cabin temperature and humidity. Once these two-dozen-odd problems were set up and understood, the team of Greene, Younger, *et al.*, went to work writing an actual specification for an airplane to meet them. No need here to detail the blow-by- (*Continued on page 90*)

Powder Compacts



. . . and not for Cosmetics. The Story of Metallurgy's New Art for Confecting Materials Previously Unknown in Industry's Cuisine — with a Homily on the Need for Less Secrecy and More Published Information and a Note on Education's Contribution

By John Wulff

IT is treading on the quicksands of metaphor to bracket the metallurgical and culinary arts, but the two have seemingly so little in common that they provide an apposite contrast to point up this story on powder compacts.

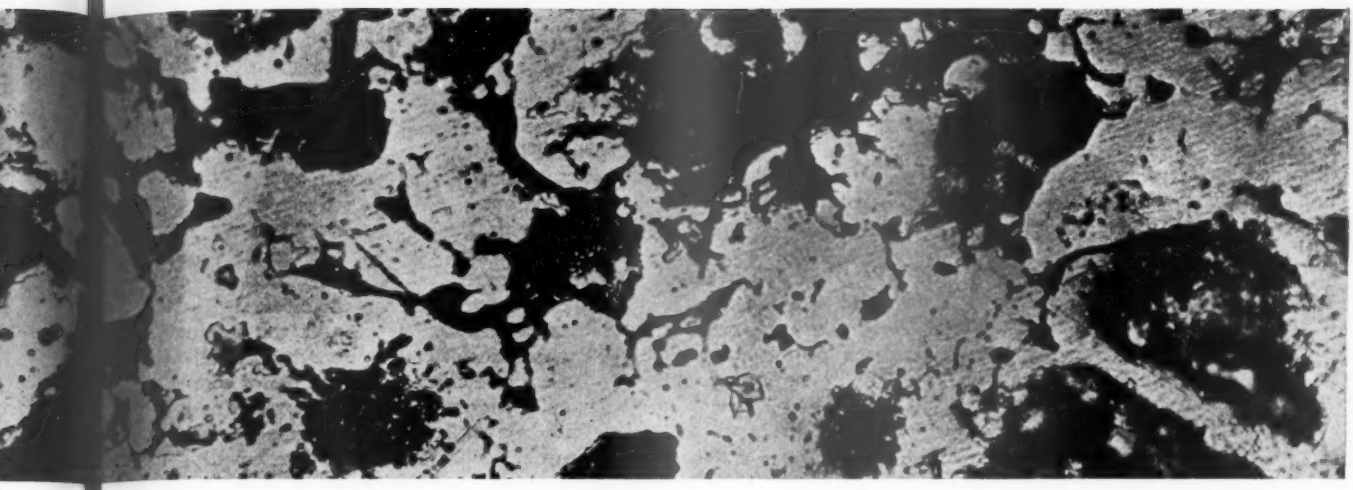
Since antiquity, for example, able culinarists * have been sophisticated enough to recognize that pastry making is so different from soup or meat cooking that its special talents and techniques unfit the artisan of one for the skilled practice of the other. Few metallurgists have ever been endowed with quite this type of acumen. It is a credit on their side of the ledger, however, that they have recognized the value of science, using it as well as contributing to it, in contrast to the culinarists who have found it more to their liking to wive on the fringe of the fine arts and frown on bespectacled science.

The metallurgical arts have continued improving processes for the winning of pure metals from ores since early Chinese and Babylonian times by methods whose essentials are the same today. Indeed the early methods for alloying, casting, shaping, and otherwise working metals have only been refined. In the 19th Century two major innovations which stem from the work of scientists changed the orthodox picture slightly. These were the refining, if not the winning, of some metals by electrolysis and the making of new bulk materials, otherwise not possible, by annealing briquetted powders. Since then both innovations have improved greatly, spurred on by technological advances in other fields. Metallurgists as merchants, artisans, or scientists know all too well that the second of the two methods can never displace the techniques of the older metallurgy or become a major producer of the metal articles of commerce. But powder metallurgy can produce useful marketable objects which cannot be made so efficiently otherwise. Thus the powder metallurgist with culinary acumen is beginning to be recognized in his own right as the pastry maker among his more orthodox fellow artisans.

What then are the powder metallurgist's activities? He is interested first in the production of fine metallic powders from natural and artificial compounds or from bulk metal. With end product in mind he mixes finely made and graded powders in combinations considered heretical for metal soups. He feeds the powders, once mixed, into a tapered die made of extremely hard steel and then with mighty presses forms them into a briquette. Thereupon he carefully anneals the resulting briquette at subfusion temperatures. The product now is ready for further fabrication or application according to more usual techniques.

The metal powders which he uses, possessing different physical and chemical properties, are produced by such varied methods as machining, stamping, spraying, condensation, chemical and electrolytic precipitation and reduction. The selection of the method is dictated by the nature of the raw materials and the requirements of the finished product. Thus, copper, molybdenum, nickel, cobalt, and tungsten powders may be obtained by heating their oxides in hydrogen atmospheres. Calcium hydride has also been employed in the reduction of the refractory oxides of titanium, chromium, and zirconium. Other oxides, like tantalum, are not reduced by hydrogen but are made by the electrolysis of fused salts. The electrolysis of aqueous solutions employing control unsuited for good electroplating is responsible for a large percentage of the powder now used. Gold, silver, and metals of the platinum group are more often precipitated from aqueous solution by reducing agents. Nickel and iron can be efficiently made by the decomposition of their carbonyls, which are gaseous compounds; but the resulting product, if pure, is usually too expensive. Copper powder can be made by most of these methods in sizes as small as 50 microns to 60 microns. Under the microscope the shape of the particles may vary from a nearly spherical to a fernlike structure, depending on the method of production. Since the cohesive quality of the powder depends on other factors besides shape and size, chemical analysis for impurities, especially oxides, must be carried out;

* This word is not in the dictionary, but it ought to be.



measurements of the apparent density and the rate at which a given weight of powder will flow through a measured orifice are also determined. The latter factor is important where the pressing operation is automatic.

With a supply of suitable metal powders available, the powder metallurgist mixes lots of different mesh sizes, as well as different elements, in tumblers or ball mills. This step is exceedingly important if pressing and annealing are to be effective later. If a certain porosity is needed, liquid or solid chemicals which evaporate in the annealing process are mixed with the metals. For special applications, other nonmetal powders are included in the mix; porcelain powder in spark-plug material and thorium oxide in tungsten to inhibit grain growth or to increase thermionic emission of vacuum tube filaments are examples. The mixing operation may extend from a few minutes to as much as a few days.

The thoroughly mixed powders are now ready for the mold or die. Much ingenuity and care are exercised in the construction of these devices. They must be able to withstand pressures up to 350 tons per square inch, and their walls should be made of materials which exhibit as low a coefficient of friction as possible. Tool steel alone or with stellite or carbide liners is often employed. With hydraulic-, cam-, friction-, or knuckle-type presses, usually capable of from five ton- to 100-ton pressure, the powder is compressed to as little as one-third or one-eighth of its original depth. The rapidity with which the pressure is applied may alter the final properties of the compact. Slow compression often results in entrapped air and in density variations. Some pressing is carried out at elevated temperatures.

Above. *Photomicrograph of an oilless bearing made from metallic powder. Note the interstices which hold oil like a sponge and exude it when the temperature of the bearing rises*

Left. *Medallion made by one blow of 50 tons per square inch. The rider and horse are of gold; the background of bronze*

The briquette made by compression is not only of greater density than the original mass but is of remarkable strength because of the welding or sintering of the original powders of the compact. In the beginning the powders are probably all covered with a film of oxide or adsorbed gas. During compression this film is ruptured because of mutual abrasion and welding of the particles which takes place at the points of contact. The reason for such adhesion is little understood.

All briquettes are usually heat-treated after compression, either in controlled atmospheres or in vacuum at temperatures well below the melting point of the constituents. Sometimes, notably in carbide tools, one of the components may even melt. Properly heat-treated compacts are usually stronger and possess more advantageous properties than untreated ones. Whether this difference is due to the reduction of volatile solid impurities, to absorption or elimination of gas, or simply to diffusion is again not known.

From powder experiments with metals which mix readily with one another in the liquid and solid states, it is known that diffusion may take place quite rapidly at even low temperatures. At elevated temperatures, grain growth may occur to an extent which makes it difficult to distinguish the material from alloys of equivalent composition produced by casting. Where diffusion and grain growth have occurred, the residual porosity of an annealed powder compact is exceedingly small. Density measurements on sintered gold and copper briquettes bring them within one per cent of the density of the bulk material. Although grain growth is not always desirable, reduction in porosity usually is. If porosity is intentionally decreased by annealing, there is naturally a slight shrinkage and sometimes even a warping of the finished compact. When the amount of shrinkage cannot be adequately allowed for, the article is machined or compressed to proper dimension and the surface finished.

ACCOUNT of some of the products already made in this manner suggests the development and possibilities of the art. Platinum in usable form was the first metal to be so produced by Wollaston in 1828. The

other high melting-point metals used in the electronics industry, namely, tungsten, molybdenum, tantalum, are similarly made. Even if fusion methods were more efficient than they now seem to be, melted products of tungsten would not be readily useful because of their excessive brittleness. Of more recent invention are the high-speed cutting tools made by compressing extremely hard particles such as carbides, borides, even diamond, with more malleable powder materials, such as cobalt. Although cobalt is fusible, the other components are not; so melting is as impossible here as with tungsten. Electric contact and welding accessories, having high conductivity and other especial physical properties, have been made by compounding silver or copper with tungsten, graphite, molybdenum, titanium and zirconium. More novel than this are the so-called oilless bearings compressed from powders which ordinarily readily fuse yet are without uniform porosity. They are made by compressing the original powders with volatile salts which disappear after the annealing, leaving a continuity of pores in the material without endangering the strength of the bearing. When oiled, the material may be said to soak up the lubricant in this system of pores, and so remains oiled for an appreciable length of time.

All of the above examples, as indicated before, can be produced only by powder technique. A great number of other objects previously made by melting methods can be more efficiently made by the powder method. Thus, casting impurities and segregations have been avoided, rigid control of composition has been obtained, and in some cases, notably with precious metals, excessive machining and scrap losses have been eliminated. Magnetic materials, thermostatic and other bimetals, stainless steel and other noncorrosive alloys, and dental alloys are but a few of the many applications.

The present industrial development of powder metallurgy as an art is definitely limited by certain natural and artificial factors. These may be more or less temporary, yet it is necessary to reckon with them. The first limitation and the most important is physical. The high pressure required to form uniform briquettes establishes definite dimensions. As the power of hydraulic presses is increased and as the special molds used are improved, it may be possible to handle larger pieces, but in such cases the cost of equipment may become excessive. The second factor worth mentioning is the patent structure of the industry. The older independents and newer workers in the field have severely criticized the larger electrical industries and their associates who control the basic patents for withholding much general and practical information. This situation has to some extent changed, but it is equally noticeable at present that some of the same critics have also begun to swamp the patent office with applications and have limited their own publications to papers which are of more promotional than constructive value. All of this has its good and its bad sides, depending on one's point of view. It indicates, however, that if powder metallurgy is to progress, published studies of the fundamentals involved in the manipulation and manufacture of powders, the mechanics of compression and annealing, and the physical and chemical properties of compacts are necessary. With one accord people within and without the art are beginning to look toward academic and other research laboratories for fundamental information.

THESE ARE NOT CAST OR STAMPED

. . . they are pressed from powder, and most of the examples scattered on this page are oilless bearings. The tube at the left contains a lining pressed from powder inside a steel tube. Bimetallic objects can be made wholly by powder-compacting methods.

These illustrations were supplied by Charles Hardy, one of the pioneers in powder metallurgy

The basic scientific problems of powder metallurgy are also the basic problems of the solid state about which theorists and experimentalists in different sciences have been worrying for some time. Why a metal powder produced by one process should have physical properties so different from those of a powder of the same metal produced by other methods may be one of the simpler problems still to be answered in this field. But why compresses made from powders exhibit such exceptional strength is certainly not easily answered. We say they are welded together. Welding connotes fusion, and, to be sure, in the customary welding process, heat and pressure are often applied and fusion results. Nevertheless, there are many examples where fusion never occurs, yet the resulting bond is remarkably strong.

The metallurgist who, in recent years, has accumulated a large amount of data on diffusion in metals and on the related problem of surface alloying at subfusion temperatures immediately brings his battery of facts into play and claims that welding results in a diffusion bond between adjacent components. The present Lord Rayleigh has demonstrated, however, that two optical glass flats in intimate contact cling together with a force of 654 pounds per square inch. The possible force is probably much larger if we consider that even two optical flats are not in perfect contact. This demonstration of the forces of cohesion is a simple assessment of their magnitude. When we understand more about the cohesive forces in single crystals, then also shall we understand more about welding and the processes of powder metallurgy. Fortunately there have been a few great experimental pioneers like Professor P. W. Bridgman of Harvard University, who have worked on this problem of cohesion and now, with the recent advancements in the theoretical physics of solids, we can already see semblances of order in what only a few years ago seemed a chaotic subject. That the results of this work will be applicable to an interpretation of the problems of powder metallurgy no metallurgist will deny who considers his subject an engineering science.

"What are the engineering schools going to do about the new developments in this field?" is a question often asked by people in industry. (*Concluded on page 101*)

New Demands on Technology

The Influence of Technical Progress Upon Social Development

By Karl T. Compton

THE BOGEY OF TECHNOLOGICAL UNEMPLOYMENT — TECHNOLOGICAL PROGRESS AND CULTURE — ADAPTING MANAGEMENT TO MODERN NEEDS

THAT our national health, prosperity and pleasure largely depend upon science for their maintenance and their future improvement, no informed person would deny." This opening sentence in the 1935 report of the Science Advisory Board to President Roosevelt epitomizes the judgment of that body of 15 prominent scientists, engineers, and medical experts on the present-day influence of technical progress upon social development. In accepting this assertion of the scientists, we may at the same time hold that there still remain many aspects of the influence of technical progress upon social development which challenge attention. I shall mention briefly four of these.

(1) *The Bogey of Technological Unemployment.* In recent years much discussion has centered around technological unemployment — the loss of work due to obsolescence of an industry or use of machines to replace workmen or increase their per capita production. Are machines the genii which spring from Aladdin's Lamp of Science to supply every need and desire of man, or are they Frankenstein monsters which will destroy man who created them? Startling examples of both viewpoints can be given. I shall only try to summarize the situation as I see it.

If we look at industry *as a whole*, without inquiring into particular cases, we would conclude that technological unemployment is a myth, because statistics show no decrease in the fraction of our population gainfully employed during the last few generations in which machine production has become important. This is because technology has created so many new industries and has so greatly increased the market for many commodities by lowering the cost of production to make a price within reach of large masses of purchasers.

In individual instances, however, technological unemployment may be a very serious social problem, as in a town whose mill has had to shut down, or in a craft which has been superseded by a new art. For example, the photoflash lamp has been a very useful development in the art of taking flashlight pictures and has largely increased activity and employment in this art, but it did suddenly take away the jobs of those who made the old-fashioned magnesium flashlight powders. Here the fact that technological unemployment does not exist as measured by over-all statistics is of small comfort to the families whose wage earners have lost their jobs.

I believe that two principles should guide us in these matters. Improved products and services should be made available to the public and not forcibly estopped to protect any entrenched business or any group of workers who would be thrown out of jobs by the change, but with this proviso: The change should be made in a manner to afford generous protection to the workers affected by it. This is a definite job for management, in which efficiency should be tempered by humane considerations (an attitude which, I believe, makes for real efficiency in the long run). Various methods are available for reducing the shock of technological changes, such as retraining workers, gradual change-over to fit the normal turnover of personnel (as followed by the telephone companies in introducing automatic switching), pensions and unemployment insurance, efficient employment agencies for labor exchange, coöperation between industries of a community to synchronize layoffs in one company with new employment in another, and so on.

In any case, I believe that the fundamental criterion for good management in this matter, as in every other, is that the predominant motive must not be quick profits but best ultimate service of the public. This is a topic in itself which deserves much elaboration, but I must leave it to your own thoughts for interpretation and application.

(2) *Technological Progress and Culture.* In discussing the influence of technical progress upon social development there is a natural tendency to emphasize only the material products of technology, forgetting that social development is more an intellectual and spiritual than a material process, and overlooking the influence of technology on the cultural aspects of society. What, therefore, is the cultural influence of technology?

The first point which strikes one, in a long-range view, is that man's achievement in every age has been made possible by, and limited by, the tools at his disposal. These limitations are, in fact, recognized in the names attached to the various stages of civilization, such as the Stone Age, the Bronze Age, or the Age of Steel.

The second significant fact is that technical progress has created opportunities for cultural development by affording the necessary time and facilities. In the ancient "golden eras" when art, literature, law, and philosophy made great advances, these were possible because the Egyptians, Greeks, or Romans possessed slaves or, in the Renaissance of Europe, serfs, who performed the menial tasks and produced the wealth which gave time and energy for intellectual and artistic pursuits to a fortunate few. Granting the intellectual greatness of Aristotle, his achievements were certainly enhanced by his freedom from ordinary work and by the services of 10,000 research assistants, put at his disposal by King

Alexander to bring him information of all sorts from all parts of the world.

In our day and generation, machines and mechanical power have taken the place of slaves in producing that large per capita productive power which makes possible time and money for education, recreation, pensions, short hours of labor, literature and news from all parts of the world, and travel. In the United States the mechanical power used is equivalent to an average of the full-time work of 50 slaves for each person.

Thus technical progress has afforded opportunities for cultural improvement. To some extent these opportunities have been utilized advantageously. We wish they were utilized better, and this, again, is a challenge to management as well as to education and religion.

(3) *The New Demands on Technology.* A survey of present-day social problems discloses some very definite directions in which technology can assist toward their solution.

Some millions of people want work — respectable, creative, remunerative, permanent employment, and not temporary makeshift jobs or doles, or the dangerous device of producing war materials beyond reasonable requirements for defense.

All, including I believe the administrators of the great relief agencies, and with only the possible exception of a few selfish politicians, would like to see it possible for the government to withdraw from the business of unemployment relief through the creation of new employment in the regular channels of industry, agriculture, and commerce. The ideal goal is reduction of Federal relief, as rapidly as regular employment can take up the slack, down to a minimum which will take care of unavoidable cases of technological unemployment in the transition period between jobs and will use this labor in the improvement of the public services and facilities for which the government is responsible. Floods, droughts, dust storms, and encroaching soil erosion have focused attention on needs for safety and conservation on a very large scale. Acts of Congress and studies of the National Resources Committee attest the concern over problems of this type.

Without giving more examples, perhaps we can summarize by saying that the unemployed want work; industry wants profits; agriculture wants new uses for its products; national resources ought to be more wisely used; natural hazards should be curtailed; labor wants shorter hours and higher pay; all the people want more wealth, lower income taxes, better health and comfort, additional facilities and commodities.

Every one of these desirable social developments can be realized only through the action of two forces: the force of better technical developments and the force of better management. Better technical developments call for scientific and engineering research, training of research workers, adequate funds and facilities, and time. Better management, whether in business or in government, provides adequate attention to scientific research and requires better understanding of problems, wiser formulation of policies, and greater efficiency in their execution.

(4) *Principles of Management.* My few years of experience as executive officer of an educational institution do not qualify me as an expert in management, for college faculties manage themselves and college trustees manage the business. From time to time a college president may be like a drop of oil in the machinery, or a flashlight in the dark, or a signpost at the crossroads, or a dentist in his office, or a prophet crying in the wilderness. But when things are as they should be, there is no friction to require oil, no darkness to require light, no bad teeth to be extracted, the faculty already knows the best way at the crossroads, and everybody is exploring the wilderness. So I cannot presume even to suggest how management problems can best be understood, wise policies formulated, and efficient execution assured. At most I can only venture to suggest certain general principles of management which seem to me to be fundamental.

The first of these is that management is an essential attribute of decent group life. Without it there is chaos, discord, and ineffectiveness. Without it there is no security; and complete freedom from controls does not give liberty but rather the worst of all subjugations — anarchy without protection. But with management comes orderly procedure and directed coöperative effort, so that the group becomes greater than the sum of the individuals which compose it. Undoubtedly the increasing complexities of modern life, due largely to technological progress, require a continually increasing degree and quality of group management.

The second principle is, at first glance, the antithesis of the first. It is that wise management involves the minimum of control and supervision consistent with reasonably smooth, coördinated, and properly oriented operation. It is an evolutionary principle that as individuals or groups grow in their ability to accept responsibility, the controls imposed on them are relaxed in order that they may accept and discharge responsibility. In this manner they develop their own powers and increase the contributions which they can make to their social group. This is a basic principle in training young animals and children, in training young executives, and in developing divisions of an organization.

The greatest of all management problems today is to determine the most advantageous balance between these two principles. How much management should be exercised and to what extent should it be centralized? The question arises in business and in government.

In industrial organization, in America at least, the pendulum is swinging definitely in the direction of less centralization of management, as well as less centralization of capital and of operating plant. The reason is that experience has shown too great centralization of control to be inefficient and also hazardous. The great desire of business now is to develop personnel who can wisely discharge responsibility and take initiative, rather than to depend upon an army of obedient, hard-working, but unimaginative employees taking orders from the boss.

Large groups always evolve more slowly than small groups; so it is not strange that governments in many parts of the world today are rapidly moving in the direction of increasing the scope of management and its greater centralization, sometimes even into the hands of one individual. This was the trend of our industrial

M.I.T. Photo

ENTRANCE

. . . to the new Rogers Building as it appears at night from Massachusetts Avenue

organizations a couple of generations ago. A fair evaluation of this tendency in governments discloses that it has in many cases come about from natural causes, such as insoluble complications resulting from the Great War, or the previous relaxing of controls before a perplexed people had developed the power to accept the concomitant responsibilities, or for other reasons. As was the case in overdeveloped industries, the dangers in this movement in governments lie in such factors as present or future mismanagement on a large scale, disregard of the rights of other groups in the confidence and ambition of their present strength, failure to develop enough independent leadership within the group, inefficiency and inability to secure any true evaluation of results or policies because of suppression of criticism.

The dangers confronting the less centralized democratic governments, on the other hand, are likely to be indecision in crises, inconsistency of policies, inefficiency in operations, continual necessity for compromise between groups. We of democracies, however, believe that in the long run there is strength even in these apparent weaknesses, because they guard against rash actions, they develop the average intelligence and responsibility of the whole population, and the whole setting encourages individual development and free enterprise. We find justification for our belief in the record of economic prosperity, high standard of living, and fundamental happiness of the people in those countries where democracy has been a spontaneous development from within, not imposed from without.

These are very important questions of management on a large scale facing most of the people of the world today. Our brethren in some countries are putting their faith in the highly centralized management of dictatorships and authoritarian states. Our brethren in other countries, and we in America, have put our faith in a form of government definitely designed to serve and not to manage the citizens, and to give maximum opportunity for free initiative and free expression. This situation offers a great opportunity to watch the results of the two sharply contrasting theories of management as an experiment on a colossal scale. God grant that our observation of this experiment be not interrupted by any action that will do irreparable damage to all people in both groups.

In all organizations there is one danger which operates insidiously from within and which, paradoxically, is greatest in those organizations which are most successful. I refer to the danger of complacency. It does not exist in a young industry in the full vigor of growth or in an older industry which, like an athlete, is kept in trim by the exercise of competition. But it is a real danger, which grows with age and success. It is greatest in an industry which (*Concluded on page 90*)

The New Bomb Bogey

BY TENNEY L. DAVIS

A war-jittery world, fooled even by a radio play describing an attack from Mars, has read with horrified acceptance news reports of a dreadful new liquid-air bomb devised and used in Europe. To get the facts about this type of bomb, The Review went to an authority on explosives, and here are his comments. THE EDITOR

IF a mass of absorbent combustible material, say a paper cylinder filled with wood pulp or powdered cork or spongy aluminum, is dipped into liquid air, the liquid air is absorbed by the combustible material — as water is absorbed by blotting paper — and the resulting mass is a powerful and sensitive high explosive. The paper cylinder becomes a cartridge of dynamite. It may be made to explode conveniently by means of a blasting cap. But since it is rather sensitive to shock, it may also be made to explode accidently by improper handling. Liquid-air explosives, or liquid-oxygen explosives, have clear-cut advantages and disadvantages and have definite limitations to their usefulness.

Liquid-oxygen explosives are so sensitive that they cannot safely be transported from place to place. They are conveniently used by loading the nonexplosive combustible material into the place where the explosive charge is desired and then by pouring upon it as much liquid air as it will absorb. Thus, the explosive is manufactured in the very place in which it is to explode. Another reason why it is not desirable to move liquid-oxygen explosives from place to place is that they are transitory. The liquid air evaporates, and the material ceases to be an explosive. This property of the explosives gives them a great advantage for certain purposes. If a stick of dynamite fails to explode after it has been loaded, it is thereafter decidedly unsafe for a workman to go into the place with pick and drill. But an unexploded cartridge of a liquid-oxygen explosive retains its explosibility only for an hour or two and thereafter may be battered by pick and drill as safely as any other inert material.

The facts that liquid-oxygen explosives must be prepared immediately before they are used, that they will not keep, and that they are readily sensitive to shock render them unfit for strictly military uses. If they could be loaded into shells, the shock of shooting them from a gun would make them explode before they had left the barrel. The gun would be destroyed, and the artillerymen would be killed.

Subject to their limitations, liquid-oxygen explosives are still useful (and cheap) for civil purposes and for the pseudo-civil purposes of the military engineer. During the World War the German military engineers used them behind the lines for demolition purposes. The liquid air was brought to the place in large steel, vacuum-jacketed cans, built like huge thermos bottles, in which the liquid air — kept cold by its own evaporation — could be preserved for a long time. Nothing, of course, could prevent its ultimate evaporation. Sometimes the liquid air was prepared where it was to be used, by portable liquefying machines transported by motor truck.

Liquid oxygen constitutes about one-fifth of freshly prepared liquid air and a larger portion of older material from which part or all of the more volatile liquid nitrogen has been allowed to evaporate. Liquid air and liquid oxygen, however, are to all intents and purposes the same thing as far as the preparation of liquid-oxygen explosives is concerned. Liquid oxygen boils at −182.5 degrees C. at atmospheric pressure. At higher pressures it boils at higher temperatures (at about 50 atmospheres it boils at −118.8 degrees C.), and it cannot be kept in the liquid state above −118.8 degrees C. no matter what the pressure which is put upon it. If a quantity of liquid air at very low temperature is confined in a strong, closed vessel and allowed to warm up, the vessel at ordinary temperature will contain compressed air, not liquid air. The pressure of the air will be enormous, and the vessel will have to be exceedingly strong to hold it. Such a vessel would evidently not make a practicable shell to shoot from a gun or a bomb to drop from an airplane.

If liquid-oxygen explosives could be loaded into bombs and if such bombs could be carried by airplane, they would still not be suitable for military use because of their great sensitivity to shock. An enemy bullet striking the bomb would certainly cause the destruction of the airplane which was carrying it. The only conceivable way in which liquid oxygen could be used practically in an explosive drop bomb is one in which the liquid oxygen is added to the combustible material, that is, one in which the actual explosive is formed, after the bomb is in flight.

During the World War the French had drop bombs which contained no explosive at all while the airplane was carrying them. Within the bombs were two compartments. One was filled with liquid nitric oxide, an oxidizing gas which liquefies readily and remains liquid at ordinary temperatures when confined under slight pressure; the other compartment contained a combustible liquid, ordinarily either gasoline or carbon disulphide. An enemy bullet striking the bomb would destroy it of course, but would not make it explode. When the bomb was released from the airplane, the little propeller on its nose, actuated by the force of the air during flight, caused a valve to open and the two liquids to mix. The bomb was thus filled with a sensitive and powerful high explosive. The bombs exploded upon impact against the slightest obstacle and were therefore more useful against personnel than for the destruction of buildings, for which purpose a bomb loaded with an insensitive explosive is needed — a bomb which will not explode upon impact with the roof but is exploded by means of a detonator after it has penetrated to the basement.

A recent news dispatch reports that the Spanish Insurgents are using against the Loyalist infantry airplane drop bombs which contain liquid air in accordance with an invention which is said to have been made in Germany. Such bombs would be practical if the liquid air were not mixed with the combustible component of the explosive, either solid or liquid, until after the bomb had been released from the airplane. The compartment containing the liquid air could not, while the plane is carrying the bomb, be kept closed to the outer atmosphere. The liquid air must be free to evaporate in order that it may keep itself at the low temperature. It would have to be introduced into the compartment of the bomb shortly before the bomb is to be used, which would be a time-consuming nuisance in wartime, and the bombs would not retain their vigor for many hours because the liquid air would evaporate away. The effective life of the bomb could, of course, be increased by building the liquid-air compartment after the model of a thermos bottle. It is doubtful whether the tight little bombs which the French used more than 20 years ago would not be better, more convenient, and probably just as cheap.

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

The President's Report

IN his annual report to the Corporation on the affairs of Technology, President Compton reviews the operation of the Institute during the past year and, looking to the future, suggests certain changes in educational procedure, poses certain academic problems, and discusses Technology's needs.

The future of architectural education, extension of the coöperative courses, further development of honors courses, an advanced fellowships fund, endowed professorships, student aid, and additional support for research — these are some of the subjects which will be presented in two summaries of Dr. Compton's report to be published in The Review. The first of these follows; the second will appear next month.

SCHOOL OF ARCHITECTURE

There is special interest at this time in the future program of the School of Architecture. Internally, it has now come again into intimate contact with our other Departments, after 22 years of enforced separation following the transfer to Cambridge of all other Departments. Externally, the architectural profession has been subjected to the simultaneous stresses arising from greatly decreased activity during the depression, technological changes in building methods and materials, and new social requirements. There are indications that these stresses will make considerable changes in architectural practice and therefore also in architectural education, although it is perhaps premature to predict what these changes will be.

The central theme of all good architecture is design, which provides for the efficient functioning of the building in a manner which is artistically pleasing and technically appropriate. Modern development of new building materials and methods, combined with social and economic pressures, is creating new demands on the architect and presenting new opportunities for him. Thus, while the central theme remains unchanged, the techniques of its application must continually adapt themselves to the evolution of the technical and social environment.

Now that the School of Architecture is again a closely integrated part of the Institute, it has new opportunities to meet the requirements of this situation. While still maintaining in its program continual emphasis on the central importance of design, it now has a wealth of opportunity for students and staff alike to secure instruction, criticism, or advice from experts in related fields.

Consider for a moment the striking quality of these opportunities. Immediately adjacent to the new quarters of the School of Architecture are located our strong divisions of Building Engineering and Construction, and of Heating, Ventilating, and Air Conditioning. A walk of 30 seconds farther along the corridor brings us to the offices of the Bemis Foundation, newly established for research on shelter. Then, after Naval Architecture, is located the work in civil engineering structures, materials testing, and sanitary engineering. After passing this we come to the Department of Economics and Social Science, which has given considerable attention to the economics of housing. Going down the corridor in the other direction we come quickly to Public Health Engineering, Acoustical Engineering, and Illuminating Engineering.

The importance to architecture of these related activities needs no amplification. The staff in Building Engineering and Construction specializes in building materials, building methods and construction, and job management, while the Albert Farwell Bemis Foundation was established as a clearinghouse for up-to-date information on materials and methods of house construction, and to foster research in these fields. The opportunities afforded to the School of Architecture do not flow in one direction only, for, conversely, the architectural group can be of continual aid and stimulation to these other colleagues.

It seemed clear to Dr. Compton, therefore, that the great opportunity, which is now open to us as to no other school in the field of architectural education, lies in a course of training which retains the central theme of design and at the same time gives the student some

M.I.T. Photo

THE DEWEY LIBRARY

. . . dedicated last June to Dr. Davis R. Dewey, beloved Professor of Economics for over 40 years, now Professor Emeritus. Serving Economics, Business Administration, Civil Engineering, and the Labor Relations Section, this new library efficiently utilizes the inadequate lecture hall, unhappily known to past students as 5–330

knowledge and some discipline in these related features of a modern structure which are requiring more and more consideration by architects. There should be a great field for young architects who, in addition to competent training in design, have some firsthand knowledge of building materials and construction methods adapted to economy and other practical requirements — even though the technical details may be left to subsidiary specialists.

Accepting the central theme of good architecture as design, which provides for the efficient functioning of the building in a manner artistically pleasing and technically appropriate, Dr. Compton recommended that the Institute proceed to capitalize and coördinate as effectively as possible our existing strong programs in design and in the various technical aspects of construction and equipment of buildings.

Dr. Compton also reported that Dean Emerson is not only in agreement with this program but had anticipated Dr. Compton's own expression of opinion by suggesting the same line of approach. Dean Emerson has already taken some initial steps to make this program effective in our new setting. In speaking of him, Dr. Compton paid sincere tribute to his able and devoted leadership of the School of Architecture during a period in which coöperation with other Departments was practically impossible because of the physical separation of the parts of the Institute, as well as during the recent period in which the effects of depression were more severely felt by architects than by any other one of our professional groups. Early foreseeing the trends, he quickly and energetically set about the establishment of our new Course in City Planning. Recognizing that training in design has wider applications than just to buildings, he has successfully directed the attention of many of our students to opportunities in the design of industrial products.

The Placement Bureau of M.I.T.; Its Policies and Services

By Nathaniel McL. Sage

Placement Officer

SOONER or later the services of the Institute's Placement Bureau become a matter of immediate interest to almost every Alumnus whether he himself needs help in advancing his career or seeks the services of a competently trained man for his firm or company. In either case it is the desire of the Placement Bureau to coöperate in a fair and impartial manner in assisting the properly qualified man to the appropriate position or to find a position for which the Alumnus is suited by training and personality.

While the Bureau is active in aiding students to find positions, as I shall describe later, assistance to Alumni occupies a major part of its program. Toward this end it maintains an Available List and, for each Alumnus on this list, an adequate personnel record containing information on business experience and qualifications. As inquiries from industry are received, those men who seem to fit the specifications set by the employer are selected, and their records are then transmitted to the employer who in turn makes contacts with the candidates whose records interest him.

M.I.T. Photo

THE CONTROL PANEL

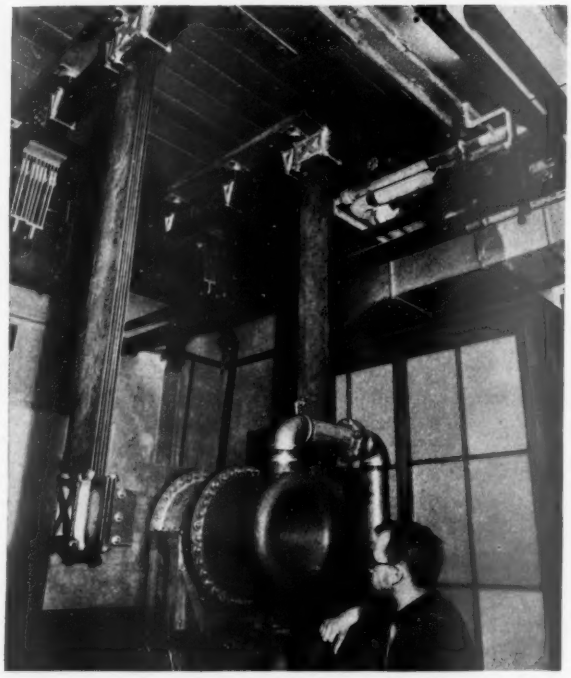
. . . in the new magnet substation now in operation, whereby is regulated the flow of electricity which energizes and the water which cools . . .

Because the Bureau feels that it must operate in a fair and impartial manner and that the elimination of all questions of fees would help to insure its doing so, no charge whatsoever is made for placement service.

It should be clearly understood by everyone that the function of the Placement Bureau is not to make a contented employee discontented with his position. Its function, rather, is to assist Alumni who find themselves in a blind alley and need help and to aid the able men who are ready for advancement but who, because of some special situation, cannot go forward with their present employers.

The following figures give some idea of the activity of the Placement Bureau during the year 1937: 4,336 letters received; 803 men placed on the active list; 556 men taken off the active list; 163 interviews with employers; 2,173 interviews with Alumni; 1,057 openings brought to our attention; 2,240 recommendations made.

In the school year 1937–1938, we had 955 industrial openings running from a recent graduate with a year or two of experience to major executives, with salary ranges to correspond. More than 3,000 recommendations were made. It is not possible to report on the percentage of success because a good many of the negotiations are still in process and also because a considerable number of men who have been assisted neglect to report their success when they secure positions.



. . . THE MAGNET

. . . wherewith Professor Francis Bitter, seen in both pictures, secures steady magnetic fields of unparalleled strength to aid research in spectroscopy, chemistry, metallurgy

Two factors determine how effective the Bureau can be to the individual Alumnus: (1) the excellence of the individual's record and (2) the marketability of his experience.

An Alumnus should remember that, regardless of his feelings as to how good he is, this feeling must be shared by others before it will be accepted by a prospective employer, with the monthly transfer of hard cash that goes with such acceptance. Marketability of experience is a picture that changes from year to year. For instance, for a number of years we have been of little assistance to structural designers and civil engineers. In September and October of this year we received more demands for junior-grade engineers in these categories than we have been able to fill.

The Placement Bureau has no power over the granting of jobs. Its function is to submit qualifications and get the interested parties introduced. The helpfulness of the Bureau to the alumni body depends on the soundness of the Bureau's recommendations. For that reason we cannot afford to gild the lily. There have been numerous cases where the work of the Placement Bureau has been ineffective because of the sketchy and inadequate records supplied to us. These instances have, of course, been corrected, but the fact that we found some makes us feel that there are undoubtedly a good many more.

There have been other instances where what might be termed a blown-up experience record has created such a feeling of uncertainty as to a candidate's sound judgment that the Bureau has been afraid to operate in the man's behalf. Out of fairness to yourself, give us a clear and accurate picture; out of fairness to the Institute, don't overstate it. If the Alumni could have the feeling that the Placement Bureau is a friendly and impartial place to come for help, it would be of material assistance to both parties.

Engineers are proverbially poor purveyors of their own abilities. We have been able to assist many men in the preparation of their experience records and in giving advice on other markets to contact. As a result of this, many have placed themselves before the Bureau had an opportunity to operate in their behalf. We are of frequent assistance to Alumni who are beginning to be troubled about where they stand. Is their remuneration or are their responsibilities in line with their age and experience? In these cases we give such information and advice as the situation warrants — sometimes a good deal, but sometimes we have to confess that we are stumped.

AID TO STUDENTS

The placement of the about-to-be graduated is handled by each of the 19 Courses, working with the Placement Bureau. The Institute's annual production is between 500 and 600 individuals. In 1937, a banner year, 1,416 interviews were held in the Placement Bureau from January through April. The total for all interviews held at the Institute would be much higher. Frequently a company interested in men from a single Course will hold interviews in that Course headquarters, and these interview figures are not included in the figure quoted above. The selection of men for interviews is very largely in the hands of the Course placement officers. All 19 Courses have one or more placement officers who devote a very considerable amount of time and energy to the proper placement of their men. The arranging and scheduling of most of this work falls on the Placement Bureau. Better than 300 qualification records are forwarded each year to companies who make contact by mail rather than by person. In all this work every effort is made to prevent any misunderstandings that might arise concerning either the jobs or the qualifications of the applicants.

As part of this program of student placement the Bureau sponsors, in coöperation with the Courses, a series of lectures on placement training. In these lectures industry has generously coöperated. They have proved exceedingly helpful in familiarizing students in the proper way to prepare and present themselves for appropriate positions.

The Placement Bureau welcomes the opportunity afforded by the Alumni Association to make this statement about its services and policies and to thank the many Alumni who have given helpful coöperation and advice and who have been alert in notifying us of openings.

How Aeronautics Started at the Institute

INTERESTING documents have recently come into our hands relating to the efforts which began in 1909 to start courses in aeronautical engineering at the Institute. In the spring of that year the Alumni Council, then newly formed and ardently anxious to prove its

worth, did so very neatly by appointing a committee to study the advisability of setting up an aeronautics course at the Institute and the ways and means. The committee appointed included Henry Howard, '89, chairman, the late Henry A. Morss, '93, and Butler Ames, '96, then a member of Congress.

The committee was informed of its appointment on June 15, 1909, and that it went promptly to work is demonstrated by this letter:

THE WHITE HOUSE
WASHINGTON

June 24, 1909.

My dear Mr. Wright:

This will introduce to you Mr. Henry Howard, of Boston, a gentleman of standing in that community whom I have known in connection with the Eastern Yacht Club and who is interested in aeronautics. He has induced the Boston School of Technology to prepare for the adoption of a course in aeronautics in its curriculum, and he is very anxious to talk to you in the matter and interest you and your brother as the chief and most advanced representatives in this science. Any time that you are able to spend on this matter I shall highly appreciate.

Very sincerely yours,

(Signed) Wm. H. Taft

Mr. Wilbur Wright,
Washington, D. C.

Apparently the committee hoped not only to get advice from Wilbur Wright but to induce him to come to the Institute. That Dr. Maclaurin had also considered this is indicated in a letter to Mr. Howard describing correspondence that he had had with Wilbur Wright.

During the summer of 1909, Henry Morss was traveling around the world, and Henry Howard prevailed upon him to visit those institutions where aeronautics had been recognized, and this Mr. Morss did. In one of his letters Mr. Morss speaks of trying to see one Professor Prandtl in Germany, who unfortunately was away on vacation. This Prandtl, then a young man, was destined to become one of the most distinguished of aeronautical engineers, and it was appropriate that he should have been present at the dedication of Technology's new wind tunnel last September.

The result of the committee's work and enthusiasm was the following report to the Alumni Council, dated April 28, 1910: "The Committee appointed by the Council of the Alumni begs leave to submit the following report: —

"First: We believe that the present state of the art of Aeronautics is such that the Institute of Technology should start a course in this subject with the least possible delay.

"Second: As a necessary adjunct to this course we believe that suitable research equipment should be installed. Attached hereto is a blue print of a possible lay out prepared by Professor Lanza. The approximate cost of such an installation complete with the necessary weighing and measuring apparatus and a small room over the end of the large pipe is $10,000. This equipment will furnish a current of air 11 ft. square, moving at a rate of 60 miles per hour and includes a 300 horse power motor of 2300 volts which would be driven by Professor Lanza's turbin generator set, the current of which is now only used for boiling water.

"Third: We recommend that the council of the Alumni bring this matter to the attention of the proper authorities at the Institute and that, if our recommendations receive their approval, either our committee or some other committee be authorized by the Institute officials to raise the necessary money for carrying out the foregoing recommendations and such others as may be considered necessary for the proper development of a course in Aeronautics."

So far so good. But the eddy which caught up all of these efforts and kept them helplessly circling was the $10,000 which apparently the Institute could not appropriate and the committee could not raise. The committee kept battering away. They were rewarded in 1913 when Jerome C. Hunsaker, '12, then a young naval officer, was detailed to the Institute and was destined to organize the first aeronautical engineering course and build the first wind tunnel. He was destined, too, as we hardly need to say, to direct the building of the latest wind tunnel, as he now is in charge of the Course in Aeronautics.

Visiting Committee Reports

IN view of the interesting origins of the Course in Aeronautical Engineering described above, it is appropriate below to cap that history with the equally interesting and most recent report of the Institute's Visiting Committee for this Course. We likewise present the report of the Committee on the Department of Modern Languages.

COURSE IN AERONAUTICAL ENGINEERING*

THE first matter on the agenda was enrollment. The limited space will accommodate only about 30 to 35 students in each of the three upper classes. Freshman enrollment in 1936–1937 was 87, but only 30 were selected to continue. Graduate enrollment grows slowly, increasing from 39 to 51 over a three-year period.

The aviation industry can absorb more first-class men. The transportation of passengers, freight, and express through the air is the only major industry, excepting gold mining, that has shown an increase every year from 1926 on, and the ratio of increase has been enormously greater than that of gold mining. The Committee favors a gradual expansion at a rate of about ten per cent a year in the number of undergraduates in this Course and the provision of facilities necessary for this increase.

On our visit to the Institute, Professor Hunsaker, '12, explained that the 7½-foot wind tunnel was not up to date and would be removed from its present building. The space now occupied by this wind tunnel is three stories in height, and to extend one of the floors in the adjacent building clean across this space would not be a

* Members of this Committee for 1937–1938 were Godfrey Lowell Cabot, '81, Chairman, B. Edwin Hutchinson, '09, Edgar S. Gorrell, '17, Donald W. Douglas, '14, the late Franklin A. Park, '95, Theodore P. Wright, '18, and George W. Lewis.

difficult matter. The room thus obtained could be used for a draughting room or for some other purpose connected with instruction in aeronautics. If the increase in running expense did not exceed the annual income from tuition fees, this proposal of Professor Hunsaker would seem to justify itself.

The investment of the funds of the Institute for revenue is exceptionally puzzling at this time because, on the one hand, we are threatened with a further decline in the value of the currency in which bond interest is paid, and, on the other hand, the business depression and possible economic changes in the future make it difficult to select stocks whose future is reasonably secured. Therefore, for a moderate sum, an increase in the plant of the Institute would seem to be a reasonable proposition, particularly if the needful funds can be obtained through the generosity of the Alumni, as will probably be the case in this instance.

The second matter discussed — whether the present language requirement of German should be cancelled — was laid on the table. The general opinion of the Committee was that the omission of German would be unwise.

The Committee approves the present policy with regard to gliding and flight training. The students who are active in this, that is, in actual gliding, are subject to their parents' consent but are otherwise left untrammeled. This sport is receiving a very great and increasing support in most European countries, where considerable sums of money are appropriated out of national funds to encourage it. Remarkable achievements have resulted, particularly in Germany, in sustained flight, in height attained, and in distance traversed without use of a motor. For testing gliding endurance, the usual practice is to soar over a particular area where there is an upward component of velocity in some prevailing wind rising over an upward slope, and the European records have far exceeded 30 hours. Our United States record is over 24 hours. For height, the upward currents generated on comparatively calm days in hot countries seem to be particularly suitable, and for distance, these upward currents have likewise been largely utilized. When one local upward current begins to weaken, the practice has been to glide to another upward current, identified by the pilot by the appearance of a cumulus cloud, which always marks the capital to a rising column of warm air. Thus by using these rising currents as steppingstones, remarkable distances have been achieved in gliding flight.

The use of the word "obsolete" with regard to the 7½-foot wind tunnel indicates, in this instance, that the tunnel no longer deals with air speed anywhere nearly as great as the speed at which commercial flight is usually conducted in this country, and while undoubtedly useful for teaching, this wind tunnel is not of much value in assisting present practice and giving advice to aircraft manufacturers on their new models.

With regard to the Institute's boundary-layer wind tunnel and the multistage wind tunnel, experiments have shown that skin friction and expenditure of power caused thereby are partly determined by whether a smooth surface allows the air to slip over it in a steady stream without eddying or whether, by some improper conformation or shape of the surface, the surface layer of air diverges from the surface over which it is passing and causes an eddy. Well-conceived experiments prevent the adoption of surfaces and shapes which show the latter undesirable characteristics under normal flying conditions. In the multistage wind tunnel, for instance, there are four diameters. The air entering at the large end is conducted into three successive contractions over a smooth curved surface having the general characteristics of a Venturi tube. Recently in the handling of natural gas in large quantity, the use of especially made valves, at which the entrance and the exit are curved and streamlined, has shown that a valve much smaller than the pipes on either side connected by it can be used with negligible increase in the resistance to the passage of the gas, just as in the Venturi tube. In fact, this is a special adaptation of the Venturi tube, where the energy lost in speeding up the air to pass through the narrower part of the tube is regained with very little ultimate loss as the speed of the air slows down again in entering into the expansion on the other side of the bottleneck.

The Committee next discussed the new up-to-date tunnel at the Institute, for which funds were contributed two years ago. Tests made two or three years ago with the great wind tunnel at Langley Field showed that by having speed tests with an air speed approximating the commercial practice in this country, which is considerably greater air speed than in Europe in commercial practice, and by using air at a high pressure, it was possible, with small models, to get close approximations of the results that would follow precisely similar shapes of commercial size. For instance, a certain English model gave results in actual practice 20 per cent different from the calculations in an English wind tunnel on the small model. This same small model tested in the high-pressure tunnel at Langley Field gave calculations within two per cent of the actual result. The new tunnel at M.I.T. is intended to bring the Institute up to date in such investigations. It can also be used down to 25 per cent of sea-level atmospheric pressure, thus imitating the density of the atmosphere at about seven miles vertical height, which is far above any height yet used in commercial practice, though by no means as high as the extreme record. At this height the miles per hour indicated on a Pitot tube gauge must be multiplied by two to give the actual speed of the airplane, which suggests the *raison d'être* of the supercharger that has made possible with a given horsepower the attainment of much higher speeds at great heights than at sea level. The Committee feels that the new wind tunnel should be used for about half the time on research work for M.I.T. and when not thus used should be available for projects of interest to the aircraft industry.

DEPARTMENT OF MODERN LANGUAGES *

IN submitting a report to the Corporation on the work of the Department, the Committee thinks it worth while to begin by outlining its conception of the broad aspects of the problem of (*Continued on page 92*)

* Members of this Committee for 1937–1938 were James M. Barker, '07, Chairman, H. Daland Chandler, '08, the late Francis R. Hart, '89, Arthur T. Hopkins, '97, John E. Aldred, Christian Gauss, and Robert E. Rockwood.

J. Rhyne Killian, Jr., '26, Editor of The Review Resigned

Frederick G. Fassett, Jr., Editor of The Review Elect

Ralph T. Jope, '28, Treasurer of the Alumni Association Elect

"As of December 31"

AFTER the publication of the January Review, J. Rhyne Killian, Jr., '26, relinquishes the editorship, which post he has graced so admirably since 1930, to become Executive Assistant to President Compton; and with the following issue The Review's eighth Editor, Frederick G. Fassett, Jr., will make his initial bow and blush. By vote of the Executive Committee of the Alumni Association, Ralph T. Jope, '28, in addition to his duties as Business Manager of The Review, becomes Treasurer of the Association, an office which Mr. Killian has held since 1929. Technically, the transmission of portfolios in each instance will occur as of midnight of December 31.

Professor Fassett is already favorably known to readers of this magazine, for in its columns there have appeared a number of articles signed by him, and since 1935 he has been one of the most vigorous of our corps of Contributing Editors, in which capacity the output of his pen has been prodigious, though anonymous, in the Trend of Affairs section.

A graduate of Colby College, a former newspaper writer, and sometime teacher at the University of Maine, he joined the Institute's Department of English and History in 1930. Since then he has advanced to the grade of associate professor, and he has acquired an especial reputation for the classes in composition which he has conducted on behalf of candidates for the undergraduate publications. As a member of the Alumni Advisory Council on Undergraduate Publications, he has also commanded the respect of the upperclassmen concerned with the management of these publications, many of whom have carried over from their freshman days indelible memories of the pains and patience Professor Fassett displayed when endeavoring to persuade them to foreswear dangling participles and to overcome a youthful fondness for sentences that could not be parsed.

Readers of The Review will be equally interested to know that Professor Fassett comes to the editorship as the unanimous choice of Mr. Killian, Mr. Jope, and myself — and that he was our first choice.

By coincidence our next issue marks the 40th anniversary of The Review, which began as a quarterly with its Vol. I, No. 1, dated January, 1899. For 12 of these 40 years Mr. Killian has been a part of The Review, and during the last eight years — the most recent fifth of the magazine's history — primary responsibility for its editorial destiny has been his. It is but a simple statement of fact, and in no sense a reflection upon his predecessors, to record that during Mr. Killian's editorship circulation has risen to hitherto unprecedented levels, and this, parenthetically, has strengthened the hands of Mr. Jope who, as Business Manager, saw to it that advertising records were broken concurrently with rises in the numbers of Review readers. Mr. Killian's present associates on The Review — and Professor Fassett — therefore derive considerable comfort from the thought that Mr. Killian's name will not disappear from the masthead after the next issue, for although he will not be The Review's principal Editor, he has consented to become a Contributing Editor.

President Compton has announced that in his new position of Executive Assistant to the President, Mr. Killian will participate in the Institute's administration and will take over some of the responsibilities carried by Vice-President Bush, who, also as of midnight on December 31, becomes president of the Carnegie Institution of Washington. Mr. Killian will also be chairman of the newly created Board of Publications of The Technology Press.

Consequently the entire staff of The Review congratulates Jim Killian without reservation upon his new appointment as an administrative officer of the Institute, and, again without reservation, we congratulate Dr. Compton.

H. E. LOBDELL, *Publisher*

THE CONTRACT HAS BEEN LET

. . for this new field house to service the new track and playing field west of Massachusetts Avenue. For details of these and other facilities made possible by alumni effort and alumni generosity, see below

When Good Fellows Get Together

The Alumni Fund Campaign: What It Totaled, What It Cost, Who Won, and How It Will Be Used

To Technology Alumni and Friends:

At the outset of this brief report, I wish to record appreciation, in behalf of all who cherish Technology, for the valiant efforts of the 2,000 or more Alumni who worked enthusiastically and effectively to promote the campaign.

In the van of these 2,000 troops stood Marshall B. Dalton, '15, last year's Alumni President; Thomas C. Desmond, '09, Chairman of the Fund Committee; John E. Burchard, '23, Assistant Chairman; and Elbert G. Allen, '00, Director of the Campaign.

If the names of the winning groups in the regional contest are to be permanently recorded in one of the new buildings, the names of the 7,000 or more Alumni, staff, and students who contributed to the fund will be engrossed in the imponderable pages of Technology's book of progress.

H. B. RICHMOND, '14
President of the Alumni Association

COMBINED efforts of Alumni, students, and friends of Technology, last year, in the Alumni Fund Drive to provide M.I.T. students with improved recreational facilities resulted in the subscription of $402,234.52 as of June 30. Of this amount, over $285,000 has now been redeemed and is on deposit in the Treasurer's Office at the Institute. Considering that the pledges were made on the basis of two years to pay, the foregoing result is most gratifying. Further payments are being made daily.

A breakdown of the pledges to the fund, as included in the final report of the campaign manager, Elbert G. Allen, '00, to the Executive Committee of the Alumni Association, gives statistical evidence of the wholehearted endorsement of all contributing groups to "build the man as well as the mind" at Technology. A breakdown of the pledges follows:

4,904	Alumni	$365,419.76
1,783	Undergraduates	24,895.77
199	Non-Alumni Faculty and Staff Members	9,177.50
103	Other Non-Alumni	2,741.49
6,989		$402,234.52

Alumni subscribers totaled 18.1 per cent of the entire number on the Alumni register for whom good mailing addresses were available. (The register includes the names of all who ever attended the Institute for one term or more.) This average of 18.1 per cent is fairly uniform for all Classes except the older ones, among which — for reason of the small number in each Class — a large variation is found. Classes having been graduated from 30 to 40 years showed a slightly larger percentage of subscription than either older or younger Classes.

The Classes of 1868, 1875, and 1878, had a perfect score, with 100 per cent of the total class membership subscribing to the fund. Other outstanding Classes graduated prior to 1900 were 1870, 1872, 1885, 1891, and 1896 — all of whom showed 25 per cent, or better, of the Class subscribing. Of those graduated after 1900, 1908 is the only Class with subscriptions in excess of 25 per cent of its entire membership.

The laurel wreath of victory to all participating groups on the basis of percentage of group contributing goes to the M.I.T. Faculty and instructing staff with its impressive record of 76.7 per cent of its membership

subscribing $27,243.49. On a geographical basis, the honor of having the largest portion of its Alumni listed as subscribers goes to East Tennessee (Knoxville) where 68.3 per cent subscribed. In the regional campaign, based on per capita subscription, Wilmington, Akron, Duluth, Vermont, Niagara Falls, Cincinnati, Pittsburgh, Hartford, Montana, East Tennessee, and Oklahoma won in their respective districts.

The average contribution from all groups was $57.55. The amount of the average alumni subscription was $74.53. Eliminating the effect of extra-large gifts (those in excess of $1,000), the average for Classes graduated 20 years or less was approximately $10, plus $2.50 for each year since graduation. Half of all subscribers gave $20 or less; one-quarter, $10 or less. Half of the fund came from gifts of $200 or over; one-quarter from gifts of $1,000 or over.

Although the solicitations to Alumni and friends of Technology stressed the desirability of making pledges to be paid over a two-year period, a large portion of the subscriptions were paid in full. As of June 30, 64 per cent of the subscribed amount had been paid. At the present time, approximately 71 per cent of the fund pledged has been redeemed. The collection cost of the entire campaign was less than 10 per cent of the amount pledged, a cost that compares most favorably with all other campaigns for which figures are available.

While the total amount pledged did not reach the hypothetical goal of the campaign, Technology men may take just pride in realizing that sizable funds are now available for beginning the job of improving the recreational facilities for Technology students.

"How," you may ask, "is this money to be spent?" Dr. Compton, in his address at the alumni banquet last June, stated that the $400,000 now available was adequate to permit the construction of the following units in the Technology program for improved recreational facilities: (1) New track and revised group of outdoor playing fields on land west of Massachusetts Avenue; (2) construction of an adjoining field house, with lockers and shower facilities on land west of Massachusetts Avenue; (3) erection of a swimming pool and an adjoining unit to provide additional locker space, showers, Athletic Association offices, and equipment rooms on the site of the present track and connected with the present Barbour Field House.

Following this plan of procedure, the Rubien Construction Company of Westfield, N. J., was awarded the contract last August to build the new track, which will be ready for use in 1939. This track has been designed by Frederick W. Rubien, Sr., who worked with the late Major Frank H. Briggs, '81, in building Technology's present track in 1914. Mr. Rubien holds the distinction of having served as secretary of the American Olympic Committee since 1914 and is considered by athletics authorities as *the* expert on track construction in the United States.

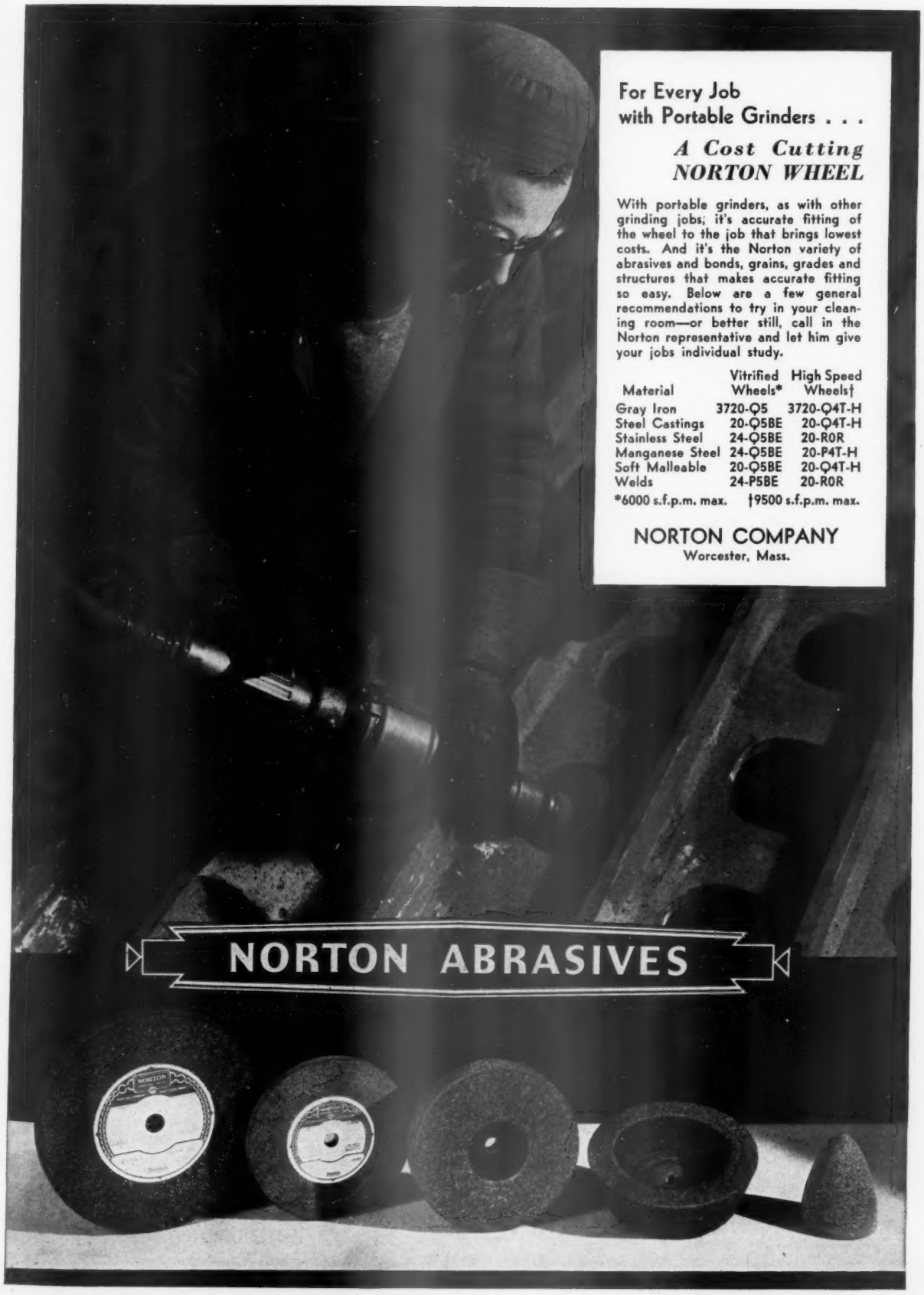
Technology's new track will measure one-quarter mile, having a 220-yard straightaway, 28 feet wide. The turns and backstretch will be 20 feet wide; thickness of the track (built of cinders), 18 inches. While constructed for use under the English system of distances, the new track will be permanently marked for metric distances as well.

Construction of the new field house to be built in back of the old Tech Coop, on land west of Massachusetts Avenue, will commence shortly. The plans recently approved include locker facilities for 432 men, three visiting-team rooms (accommodating approximately 30 men each), two coaches' rooms, one officials' room, one rubbing room, and adequate shower, equipment storage, and toilet facilities. A much needed sun deck will be constructed on top of the building.

Designs for the new swimming pool and additional Athletic Association offices are not yet completed. Tentative plans call for the construction, in one building, of a recreational and competitive pool, 75 feet long by 42 feet wide, with a shallow pool, 20 feet long by 42 feet wide, for beginners. This pool unit, together with Athletic Association offices, will be designed so that other athletic and recreational structures may be added and harmoniously related as funds become available.

The Record of the Classes

Class	Per Cent Subscribed	Average Subscription	Average Per Capita
1868	100.0	$ 15.00	$ 15.00
1869			
1870	28.6	30.00	8.57
1871			
1872	25.0	250.00	62.50
1873	14.3	1,000.00	142.80
1874			
1875	100.0	14.06	14.06
1876	23.1	340.00	78.50
1877	8.7	17.50	1.52
1878	100.0	19.38	22.14
1879	4.0	10.00	.40
1880	6.7	150.00	10.00
1881	22.2	195.83	43.50
1882	7.7	150.00	11.54
1883	16.7	44.00	7.33
1884	17.4	226.25	39.30
1885	28.3	56.65	16.04
1886	14.6	177.58	25.99
1887	21.4	160.65	34.30
1888	17.9	125.58	22.49
1889	13.3	250.13	33.20
1890	16.9	134.80	22.83
1891	25.5	67.86	17.30
1892	17.2	217.30	37.47
1893	20.6	114.50	23.58
1894	14.6	342.77	50.03
1895	23.0	187.13	42.90
1896	26.1	180.84	47.12
1897	18.5	395.80	73.36
1898	21.5	98.41	21.14
1899	16.0	169.90	27.18
1900	16.8	92.60	15.54
1901	21.2	648.32	137.60
1902	19.3	106.50	20.57
1903	21.8	75.69	16.53
1904	16.3	90.97	14.82
1905	17.9	151.60	27.07
1906	22.0	113.58	24.98
1907	21.2	180.40	38.30
1908	25.8	54.84	14.16
1909	18.0	118.16	21.23
1910	19.3	79.30	15.28
1911	21.6	80.00	17.30
1912	20.5	80.25	16.41
1913	19.8	79.63	15.79
1914	21.9	91.95	20.69
1915	18.0	82.39	14.84
1916	19.3	125.97	24.29
1917	17.9	70.54	12.63
1918	14.3	57.90	8.28
1919	16.0	46.45	7.42
1920	17.0	71.64	12.15
1921	15.4	46.64	7.17
1922	18.4	47.24	8.70
1923	16.9	43.42	7.34
1924	17.6	58.58	10.29
1925	13.4	34.57	4.64
1926	22.4	41.23	9.23
1927	18.5	32.40	5.99
1928	22.2	38.28	8.49
1929	15.4	29.00	4.45
1930	14.8	26.41	3.91
1931	14.4	26.90	3.87
1932	14.7	16.26	2.39
1933	18.4	23.10	4.26
1934	18.5	20.61	3.82
1935	17.5	18.29	3.20
1936	18.0	16.28	2.93
1937	16.2	13.90	2.24
All Classes	18.1	$ 74.53	$ 13.45


For Every Job
with Portable Grinders . . .
A Cost Cutting
NORTON WHEEL
With portable grinders, as with other grinding jobs; it's accurate fitting of the wheel to the job that brings lowest costs. And it's the Norton variety of abrasives and bonds, grains, grades and structures that makes accurate fitting so easy. Below are a few general recommendations to try in your cleaning room—or better still, call in the Norton representative and let him give your jobs individual study.
Material | Vitrified Wheels* | High Speed Wheels†
Gray Iron | 3720-Q5 | 3720-Q4T-H
Steel Castings | 20-Q5BE | 20-Q4T-H
Stainless Steel | 24-Q5BE | 20-R0R
Manganese Steel | 24-Q5BE | 20-P4T-H
Soft Malleable | 20-Q5BE | 20-Q4T-H
Welds | 24-P5BE | 20-R0R
*6000 s.f.p.m. max. †9500 s.f.p.m. max.
NORTON COMPANY
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NORTON ABRASIVES

NEW DEMANDS ON TECHNOLOGY

(*Concluded from page 79*)

holds a monopoly, for then are absent those incentives of struggle for survival and ambition for success. It is then easy to fall into a "public-be-damned" attitude, or to be content with the *status quo* — forgetting that law of nature so well expressed by Francis Bacon 300 years ago: "That which Man altereth not for the better, Time, the great Innovator, altereth for the worse."

Thus, for example, it seems to me that by far the greatest merit in the Sherman Antitrust Law of this country lies not in its protection of the public against exploitation by industrial trusts but lies rather in its protection of the public and of industry itself against the dangers of complacency which lead to stagnation of industry. By maintaining competition there is insured a continuing incentive to progress and to ever improved service of the public, and thus to maintenance of virility in industry itself.

For reasons such as these, government monopoly or extensive government control appears to me to be the greatest of all possible dangers to any country, even though it may be possible for such control to be, for a time, efficient and vigorous. All the dangers of complacency and stagnation which are inherent in an industrial monopoly are raised to the highest degree in a government monopoly — for this represents the maximum protection against competition and the minimum of inducement to continual progressive policies.

In this problem of management, whether on an industrial or a governmental scale, there seem to be certain basic principles of wise action: First, minimize the danger by avoiding monopolistic control; second, hold rigidly to the cardinal principle of providing always the best possible service to the public; third, keep continually in mind the lesson taught by science — that there appears to be no limit to the progress possible through sustained intelligent effort.

My final suggestion of a principle of management is the outgrowth of my contacts as a scientist. Experience has amply demonstrated a fact that at first sight seems surprising. It is that the most significant technological advances have not come from direct efforts to make them, however well organized, but as unexpected by-products of scientific work undertaken for quite other objectives — usually for the satisfaction of scientific curiosity. Organized, directed effort is very effective in perfecting the details of a product or its production, but not in its initial discovery. This contrast is greater the more epoch-making is the new discovery.

The logical reason for this is not hard to understand. Really epoch-making discoveries are relatively unpredictable in advance. The practical solution to a difficult problem may come from any one of a multitude of directions. Really new ideas do not come to order and are not pulled out of a hat, and who can tell in whose brain they will germinate. If an industrial research laboratory had been established a century ago to improve lamps, it would have investigated inflammable oils and gases, wicks, chimneys, and refractories. Not conceivably would it have paid attention to the leakage of electric charges through the air or to the behavior of magnets, wires, acids, and the legs of frogs. Yet from these actually came the modern lighting devices.

I believe that the same logical and psychological principles operate in the field of management generally. A highly centralized and organized form of management may be very effective in performing the specific functions assigned to it in the manner stipulated by headquarters, but it is not a favorable type of organization in which to take advantage of the potential genius inherent in the group which, if given opportunity, may produce better leadership, develop more advantageous objectives and more effective operations.

So I believe that experience, logic, and human psychology all support the view that that type of management is most likely to be successful in the long run which directs and inspires but does not too rigidly control, which offers large opportunity for initiative and for criticism, which has faith in the mass judgment of an intelligent group and in the genius which may appear in unexpected quarters. It is qualities like these which are basic to the type of management which has found favor and success in this country, in the home, in business, and in the organization of our government itself.

HIGHER HIGHWAYS FOR TOMORROW

(*Continued from page 73*)

blow account of the months that lay between the final specs and the emergence of the finished article. Suffice it to say that in the spring of 1937 the Air Corps took delivery of a modified Lockheed Electra which is carried on the records as the XC-35 airplane. It differs from the standard Electra mainly in that its fuselage is circular in cross section (for obvious reasons). Construction is conventional except that very careful attention was paid to sealing all joints and openings. Fore and aft, it contains two compartments, either or both of which may be pressurized.

The power plant of XC-35 consists of a pair of 550-horsepower Pratt and Whitney Wasp engines, equipped with turbosuperchargers. Each exhaust-driven turbine wheel carries two impellers on a common shaft, one to supply air to the engine carburetor, the other to supply air for cabin supercharging. For experimental purposes, the cabin superchargers may be used either in series (for wider pressure range) or in parallel (for greater capacity). With this arrangement it has been found possible to operate the airplane at 30,000 feet with a cabin-pressure equivalent of 10,000 feet or less. Under such a condition the differential pressure, inside to outside the fuselage, is of the order of 5.5 to 6 pounds per square inch.

Plenty of "bugs" emerged when XC-35 was in the shakedown stage. Minute leaks in the shell had to be run to earth and calked. Then, at high altitudes and low temperatures, persistent ice formation inside and outside windows made pilotage difficult. Strange and unexpected troubles turned up with instruments, in hydraulic accessories systems, and in engine and propeller oil systems, due to long exposure to extreme cold. But one by one such troubles are being licked. Major Greene and Captain Alfred H. (*Concluded on page 92*)

Cooperative GLF Office Building Ithaca, N. Y.

NEW GLF BUILDING GETS MODERN HEATING

American Warming & Ventilating Co. Installs Webster Moderator System

Concealed Webster Radiation

Ithaca, N. Y.—Built during 1936, the modern, five-story office building of the Cooperative Grange League Federation stands as a tribute to the careful planning and sound business management of the Cooperative officials.

Working on a limited budget, officers of the GLF sought long life and low maintenance cost in selecting equipment.

Study of the performance records of Webster Systems of Steam Heating in scores of installations convinced Grange officials that the Webster Moderator System was the soundest possible investment for the heating of their new building.

The Webster Moderator System provides **balanced** heating service. Heat is delivered continuously to all radiators and the entire building is comfortably heated regardless of the severity of the weather and without overheating in mild weather. Heating costs are held continuously at a minimum.

The installation includes 70 concealed Webster System Radiators. The grilles of these "out-of-the-way" concealed radiators harmonize with the modern interior and increase available floor space. All cast-iron radiators used in the building are equipped with Webster Three-Point Valves to insure maximum flexibility.

Two Webster Boiler Protectors guard against accidental low water in the low-pressure heating boilers. If water is lost from a boiler accidentally, the Webster Boiler Protector automatically maintains emergency level and provides the operator with definite indication that water has been lost.

The Webster System was installed in the GLF Building by the American Warming & Ventilating Co., well-known heating contractors of Elmira, N. Y. The building was designed by Arthur N. Gibb, a leading Ithaca architect.

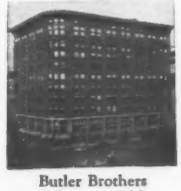
Butler Brothers, Chicago, Ill.

BIG MODERNIZATION JOB BY WILLIAM LEES, INC.

Heating Changes Completed in Short Time Effect Big Saving For Chicago Building

USE 8-ZONE WEBSTER SYSTEM

Chicago, Ill.—The heating installation in the great central warehouse and office building group of Butler Brothers Store was modernized during the early fall of 1935. The previously uncontrolled heating system was orificed throughout to balance distribution and placed under control of an 8-zone Webster EH Moderator System. This number of zones was necessary to provide for different conditions of occupancy and the needs of different tenants as well as the requirements of Butler Brothers own operations.



Butler Brothers Baltimore, Md.

This modernization program, one of the largest central control heating installations ever made, was completed in a remarkably short time by William Lees, Inc., prominent Chicago heating contractors. The fall and winter of 1935-36 served as a period for adjustment and perfection of operating procedure.

An idea of the savings possibilities is afforded by the record for five months during this adjustment period, from January to May, 1936, inclusive. During this period a measured savings of 420.16 tons, equivalent to $1218.46, was attained.

Under the contract covering the modernization program Butler Brothers reserved the option to permit payment to be made out of current monthly savings as made, or to complete payment for cash. It is significant that with this privilege Butler Brothers elected to complete payment for cash early in the second season of operation.

A similar modernization program has since been carried out in the Baltimore warehouse building of Butler Brothers, with the Baltimore Heat Corporation acting as Modernization Heating Contractors.

Baltimore branch of the Federal Reserve Bank of Richmond, Baltimore, Md.

COMPLETE MODERNIZATION OF RELATIVELY NEW BANK

Baltimore Heat Corporation Gets Excellent Heating Results in 9-Year-Old Bank Building

WEBSTER MODERATOR SYSTEM

Baltimore, Md.—That heating systems sometimes become obsolete before they become old was demonstrated in the five-story building which houses the Baltimore branch of the Federal Reserve Bank of Richmond.

When constructed in 1927, the Federal Reserve Bank building was modern in every detail. In 1936, only eight years later, the rapid developments in heating science led the Baltimore Heat Corporation, well-known firm of heating contractors, to install Webster Central Control as a necessary step in keeping the heating system up-to-date.

The building owners authorized the Baltimore Heat Corporation to carry out the Webster Heating Modernization Program.

With the Webster Moderator System, steam is delivered continuously to all radiators without excessive heating, thus correcting the distribution weakness of the old installation.

The need for a central heating control responsive to outdoor weather conditions has been met by an Outdoor Thermostat, which adjusts the steam supply automatically with every change in weather or wind direction. A manual Variator permits the operator to modify the effect of the thermostat.

"The Webster Moderator System has enabled us to maintain uniform, adequate temperatures throughout the building," says F. W. Wrightson, Assistant Cashier. "There has been a noticeable improvement in the cleanliness of our building since the introduction of district steam service. This means better heating service."

Use of district steam for heating was authorized because of its economy and dependability in combination with the Webster Moderator System.

For further facts about comfort and economy in heating new buildings as well as in modernization of existing installations, address

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HIGHER HIGHWAYS FOR TOMORROW

(*Concluded from page 90*)

Johnson (assigned as chief pilot of XC-35) and a group of Air Corps technicians have spent well over 200 hours in the air with the ship, most of it at levels that will not support human life, and never once has the emergency supply of oxygen carried aboard been turned on. As a result of the success of the work, the late chief of the Air Corps stated that pressure-cabin operation has been shown to be entirely practicable and the construction of dependable and effective pressure-cabin machines to be definitely within the manufacturing capabilities of the present aircraft industries of the United States.

And so, when the committee that was to award the Collier Trophy "for the greatest achievement in aviation in America" for last year finished its deliberations, it is not surprising that the decision favored the Air Corps for its high-level work. What the Army has discovered with XC-35 will not only be of tremendous benefit to all service aviation in developing a more efficient national air defense but is already providing great impetus to the high-level, overweather commercial flying of tomorrow. At least two pressurized transport machines are under actual construction in this country: the four-engined Model 307 Boeing and the two-engined Model 20 by Curtiss-Wright. The new Douglas DC-4, now being test flown, is not arranged for cabin pressure at the moment, but the engineering work necessary for conversion is completed, and there is little doubt that future models of this machine will be cruising with passengers at 25,000 feet with the rest of them.

Air travelers of 1942, shuttling back and forth from Coast to Coast or across the Atlantic in 10 to 12 hours at levels high above the discomforts of local storms, may well look back and thank Major Greene and his flying machine for the work they did in 1937.

THE INSTITUTE GAZETTE

(*Continued from page 85*)

modern language instruction at the Institute. Thereby the Committee feels that it can better present the reasons behind specific recommendations. Decision as to the inclusion of a subject in any curriculum is naturally determined on the basis of certain principles. These are apt to be reasonably apparent in the case of scientific subjects related to the planned courses of technical instruction, but much more difficult to enunciate for those subjects which fall in the category of the humanities. The aim of the Institute is not merely to graduate skilled technicians. Rather, our ideal is to provide a source of educated men, thoroughly grounded in the technical aspects of an engineering or scientific profession, who shall also have some correlated knowledge of the general work and life of the world. Accordingly we have the humanities in our curriculum, with modern languages among them. The Committee has endeavored to find out what may reasonably be considered as funda- (*Continued on page 94*)

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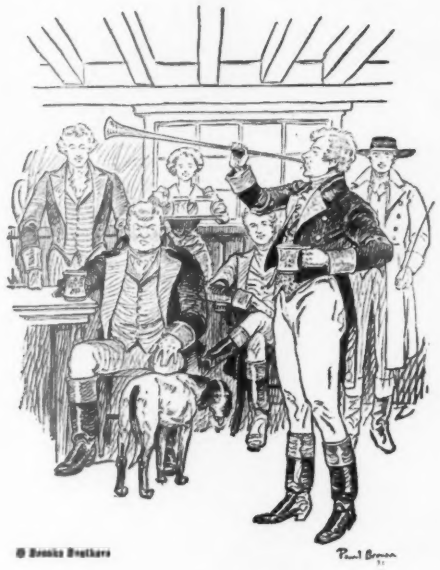

INFORMATION ON M.I.T.

THE TECHNOLOGY REVIEW BUREAU exists to supply authoritative information to anyone interested in details regarding the Massachusetts Institute of Technology. It serves as a clearing house for inquiry and aims to further the spread of exact information regarding entrance requirements, outline of courses, subjects of instruction and other information which may be of aid to the students considering undergraduate or graduate study at the Institute.

The Institute publishes a variety of bulletins, as well as a catalogue of general information essential to the entering student. The Technology Review Bureau will be glad to send, gratis and post free upon request, one or more copies of any publication listed below, or to forward any special inquiry to the proper authority.

Ask for the following pamphlets by their descriptive numbers

1: For general information, admission requirements, subjects of instruction, ask for Bulletin 1.

2: For announcement of courses offered in Summer Session, ask for Bulletin 2.

3: For information on courses in Architecture, both Undergraduate and Graduate, ask for Bulletin 3.

4: For a popular presentation of Educational Opportunities offered at M.I.T., ask for Bulletin 4.

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THE INSTITUTE GAZETTE

(*Continued from page 92*)

mental principles for the inclusion or exclusion of modern languages in our courses of study, for it is particularly important that these decisions should be determined by principles and not merely by tradition.

The inclusion of modern languages in college entrance requirements and the curricula of our colleges appears to have been too often determined from the conventional viewpoint. It is not the purpose of this report to discuss the problem of any institution other than our own. In the liberal arts colleges, decisions seem to have been influenced by the conventional attitude toward modern languages as a part of an education and also by the fact that a certain number of students wish to take such courses to prepare themselves for specialized work in teaching or research in the modern language field. The Institute fortunately is in a position to take a scientific and, if necessary, unconventional attitude on this matter.

This is a practical problem. The inclusion of a subject in the curriculum costs the Institute money for salaries, space, and equipment and costs the student valuable time which might be spent on something else. The two principles which we think should determine the inclusion or exclusion of modern languages in the curriculum of the Institute are as follows: (1) Is this subject a necessary or desirable tool for increased scientific accomplishment? (2) Is this subject a necessary or desirable part of the liberal education of our graduates?

With regard to the first principle, modern languages are of some importance in certain Courses as a tool for increased scientific accomplishment. Examples are the usefulness of French in reading the important architectural literature written in that language and, in the case of German, the ability to understand the scientific literature in such fields as physics and particularly chemistry. The technical literature in Spanish and Italian does not appear to be generally important enough to warrant emphasis. The modern language need of students of science and engineering is primarily one of technical vocabulary. They of course should have a knowledge of the simple structural characteristics of the language, such as can be gained from classroom instruction, but no vocabulary control adequate for the reading of scientific works can possibly be gained in any reasonable allotment of time in the curriculum. The individual student must take the building of a vocabulary as a personal problem and dig it out for himself in his own time.

The Committee believes therefore that French or German can be a valuable tool to students in certain courses; that preparatory school modern language instruction should have given a structural background, on the basis of which students who have studied the language should be able to dig out their scientific vocabularies by themselves; that where such preparatory school training is lacking, the Institute's courses for these students should be confined to this elementary structural requirement and definitely pointed to that end.

(*Continued on page 96*)

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THE INSTITUTE GAZETTE

(Continued from page 94)

With regard to the second principle, previously stated, consideration of modern languages as a necessary or desirable part of the liberal education of our graduates brings out the following points: A foreign language may be useful as a means of communication in foreign travel or in personal relations with foreigners. It may be valuable to those who enter businesses which involve residence in a foreign country. Knowledge of another language can result in a general broadening of the mental horizon and a certain cultural satisfaction.

The Committee's comments on these points are as follows: (1) Relatively few find that modern languages as at present taught generally in this country are of much value as a means of communication with foreigners whether at home or abroad. (2) Relatively few enter businesses which involve residence abroad. We do not think that these two points are important to enough individuals to justify any general language requirement. (3) Modern languages effectively taught can serve as an extremely valuable broadening influence, but unless they are presented in such a manner as to arouse a definite interest, the Committee feels that much of the time spent on them is wasted.

From the foregoing reasoning, the Committee draws the following conclusions: (1) The aim of each modern language course given at the Institute should be clearly defined. (2) The ability to read foreign technical literature should be required in the Courses where those in charge ascribe importance to such ability. (3) The Institute should provide carefully planned elementary modern language instruction for students who are specializing in fields which require it and who have not had preparatory school elementary language training. Eventually it may be possible to eliminate such instruction by substituting corresponding entrance language requirements. (4) The responsibility for acquiring a technical reading vocabulary should be placed on the individual student and not on any Institute modern language instruction. (5) Knowledge of at least one modern language can be an important element in the liberal education of our graduates. For this reason the Institute should continue to provide broad modern language instruction for such students as elect to take it among their humanities. (6) Such language courses should be carefully planned to have intrinsic interest and not be allowed to disintegrate into the conventional, dull drudgery of grammar rules, oral translation of the foreign language, and written translation from English into the foreign language. (7) The basic emphasis of these courses should be on the language as a medium for the communication of ideas, and interest should be stimulated by such means as phonograph records, foreign films, and extracurricular conversation clubs. (8) The constant attempt of the Department should be to discover new ways of vitalizing modern language instruction, even at the expense of the conventional and traditional methods which have been used generally for so many years.

(Continued on page 98)

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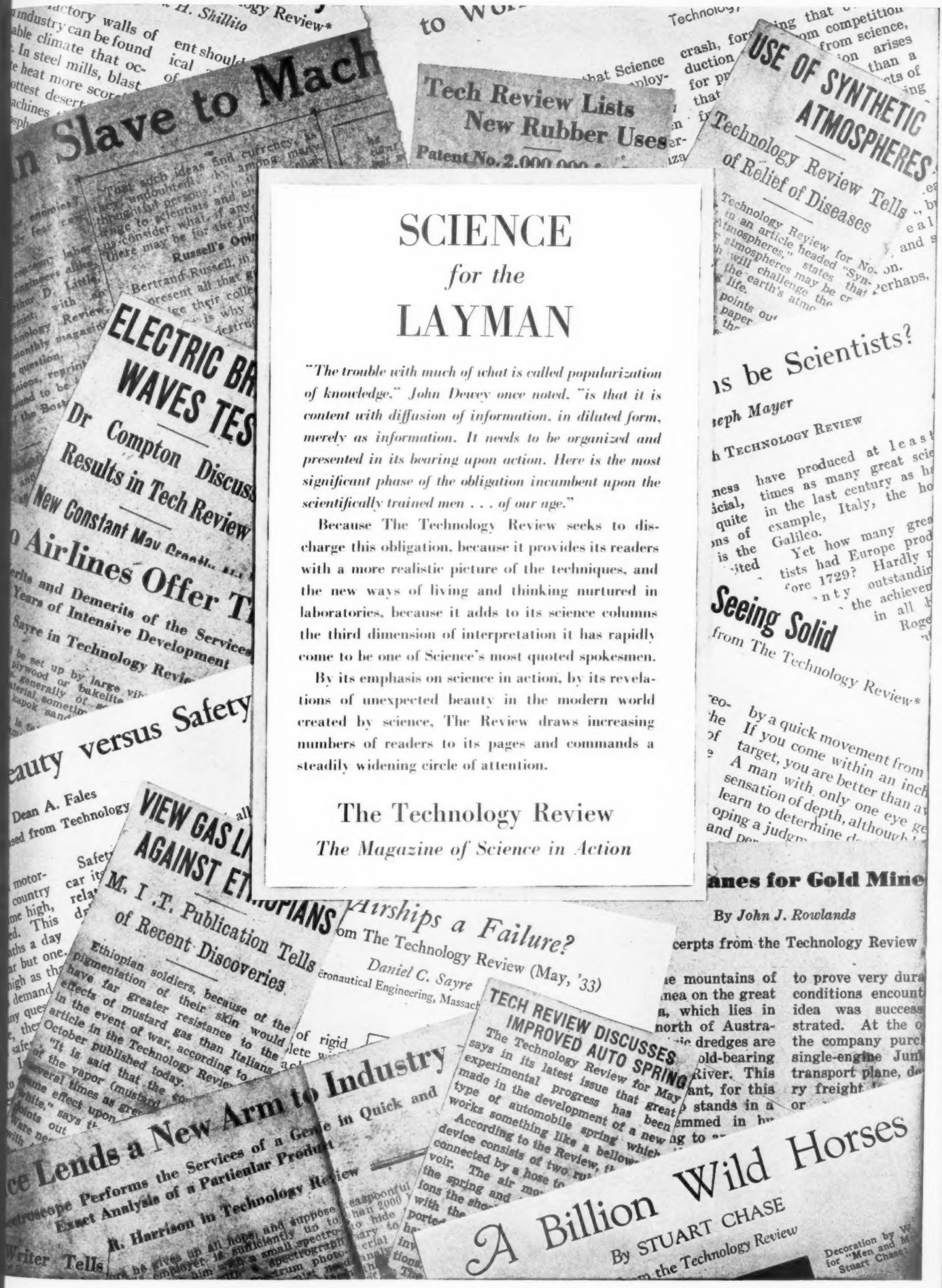
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Ethiopian soldiers, because of the pigmentation of their skin would have far greater resistance to the effects of mustard gas than Italians
Airships a Failure?
om The Technology Review (May, '33)
Daniel C. Sayre
ronautical Engineering, Massach
TECH REVIEW DISCUSSES IMPROVED AUTO SPRING
The Technology Review for May says in its latest issue that great experimental progress has been made in the development of a new type of automobile spring which works something like a bellow
According to the Review, the device consists of two ru connected by a hose to voir. The air mo the spring and fons the sho with the porte
Lends a New Arm to Industry
Exact Analysis of a Particular Product
R. Harrison in Technology Review
Writer Tells
Seeing Solid
from The Technology Review*
Men for Gold Mine
By John J. Rowlands
cerpts from the Technology Review
A Billion Wild Horses
By STUART CHASE
the Technology Review
Decoration by W
for "Men and M
Stuart Chase
SCIENCE
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"The trouble with much of what is called popularization of knowledge," John Dewey once noted, "is that it is content with diffusion of information, in diluted form, merely as information. It needs to be organized and presented in its bearing upon action. Here is the most significant phase of the obligation incumbent upon the scientifically trained men . . . of our age."
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THE INSTITUTE GAZETTE

(*Continued from page 96*)

The Committee recognizes that reforms along this line will not be immediately possible of complete accomplishment but believes, however, that this is the direction in which we should move as an institution.

Dard Hunter Paper Museum

THOSE of us who have seen plans for further allocation of space in the Institute's new Rogers Building are much interested in a blueprint which bears a rectangular reservation marked "Paper Museum." The significance of that notation, first revealed in *Footnotes*, the bulletin of The Friends of the M.I.T. Library, lies in the news that the great collection of handmade papers gathered from all parts of the world by Dard Hunter, internationally recognized as the greatest living student of papermaking, is coming to the Institute. Furthermore, Mr. Hunter himself will shortly join the staff of Technology as curator of the Dard Hunter Paper Museum.

Descended from a family whose name has been associated with printing in Ohio for more than 120 years, the roots of Dard Hunter's lifelong interest in the history and traditions of papermaking may be traced from Ohio to Virginia, where the Hunters first printed in the New World, and thence to Scotland, the soil from which the family printing traditions sprang.

No one interested in the making of fine books can be unaware of the unique accomplishments of Dard Hunter. From his private press at The Mountain House, Chillicothe, Ohio, came what is, perhaps, the first book of which the same man was the author, illustrator, maker of the type and paper, as well as the printer. Dard Hunter's books are, by necessity, limited to small editions. In his eagerness to share with others what he has learned, his books are not only printed on the finest papers but several are richly interleaved with numerous specimens of rare and beautiful papers made by primitive methods in various parts of the Far East.

For nearly 40 years Dard Hunter has searched the remote places of the globe in his studies of primitive methods of making papers. He hunted in Mexico and the islands of the South Pacific Ocean for tools and specimens of the primitive paper mills and made an

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exhaustive study of papermaking in China, Korea, and Japan, where paper enters into almost every phase of life, from the most sacred religious rituals to the prosaic purposes of clothing and shelter. To those who may think the study of paper must be a dry and technical pursuit, we recommend Mr. Hunter's "Papermaking in Southern Siam," the chronicle of a journey to the primitive paper mill at remote Bangsom, operated by Tym and Piung Niltongkum and their two daughters. Here is the story of lovely Siamese papers made from the bark of the *khoi* tree, the preparation of black dye from the hulls of betel nuts, and the staining of the dull black temple papers on which Buddhist priests in canary-yellow robes write in yellow ink.

Dard Hunter is a native of Steubenville, Ohio, and was educated at Ohio State University, the Graphische Lehr und Versuchs-Anstalt and the Kunstgewerbe Schule in Vienna, and the Royal Technical College of London. In 1931 Lawrence College awarded him the honorary degree of doctor of literature. From 1903 until 1910 Mr. Hunter was art director of the Roycroft Shop at East Aurora, N. Y., home of the late Elbert Hubbard, where he designed more than 100 books. In 1919 he settled himself at The Mountain House and began there the production of handmade paper for his books, of which five of a total of nine were printed in type designed and hand-cast by the author. Last year, however, Mr. Hunter announced that he would discontinue the use of hand-cast type and that his books, "Papermaking in India," "The Story of Paper," and "Papermaking in Burma and Indo-China," now in preparation, would be printed in hand-set foundry type on paper appropriate for the subject.

We hope that the Dard Hunter Paper Museum at the Institute will include not only his books and his distinguished collection of papers and papermaking implements but the very paper-mill equipment with which he has proved himself a superlative craftsman, as well as a student whose research on the history of the universal and fundamental medium for the advancement of thought — paper — is a notable contribution to culture.

Our Lady Skipper

ALWAYS the unfulfilled desires of man respond to a fairy tale. Freely shaking off his familiar existence, he steps into a world where obstacles, although present — sometimes in extraordinary amount — are surmounted surely. Achieving something of this fairy-like release, Marion Rice Hart, '13, has written of an adventure which transcends the mere tale in being real.* Wearying of her colorful and comfortable establishment at Montfavet, France, she suddenly announced that she intended to buy a yacht. She "liked yachting and, when the boat was going . . . could tell the front from the back end."

Molly Hart's independence and unpredictableness and her delightful sense of humor carried her triumphantly through the ordeal of yacht shopping to the purchase of the auxiliary ketch *Vanora*. (*Concluded on page 100*)

* "Who Called That Lady a Skipper?" New York: Vanguard, 1938. 313 pages, $2.75.

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THE INSTITUTE GAZETTE

(*Concluded from page 99*)

Training as a chemical engineer at M.I.T., research in the General Electric laboratories in Schenectady, work on a geological survey of the West Point sector, and four years of stone carving would not seem to be nautical preparation. But they developed adaptability and ingenuity in one who seems constantly surprised at her success in new fields.

Finding the repair price beyond her means, Mrs. Hart set to work on the 90-foot ketch herself, aided by a sculptor and his wife, a Greek girl "who had just finished giving a course of lectures on philosophy," and Rusty, a young cousin who "still had three weeks of his Easter holidays." This was in April, 1936. In August the trip began, from East Cowes for the Bay of Biscay, thence through the Mediterranean and the Red Sea, to Singapore, Bali, Komodo — to mention only a few of the ports of call.

Mrs. Hart has written this part of the book as a series of letters to her brother, who must himself be a sympathetic and pleasing person, as she writes with freedom and humor a lively account of difficulties and successes, giving a clear and entertaining picture of personalities and places. Discouraged by encounters with unfortunate skippers, Mrs. Hart practiced navigation through the Mediterranean and at Port Said took over herself.

After the first 24 hours she wondered how any sailors ever live to grow up, but at Port Sudan "we came in . . . in grand style and nobody nearly so surprised as I." By December 25, 1937, this lady skipper and her crew had arrived at Banda, British India, where they paused for a little mountaineering, and Mrs. Hart wrote Tom: "That is all for the present." We hope when she comes home through the Pacific, her facile pen will give us the rest of the story.

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POWDER COMPACTS

(*Concluded from page 76*)

This may be answered if we consider how dependent powder metallurgy is on the techniques of engineering and the pure sciences. For an educational institution to surround powder metallurgy with a halo in the form of a complete curriculum not only is unsound pedagogically but furthermore would be dangerous for both teacher and student. After all, we know that the best apprenticeship in engineering practice is still obtained in industry itself. To satisfy the needs of some students in metallurgy, chemical engineering, and physics, as well as graduate engineers in the local industries, the Institute's Department of Metallurgy has established a short elective seminar course in powder metallurgy. This is to be followed by laboratory research during the second term. With the coöperation of research workers and engineers, half the time of the seminar course is devoted to listening to reports of problems encountered in practice. The remainder is given to a discussion of original papers from scientific or engineering periodicals which bear on the subject. Fortunately such papers have a definite relationship to the student's courses in other fields and thus help to widen his horizon without dulling the sharpness of his endeavors. With a research laboratory in powder metallurgy planned for next term, we hope it will be possible to contribute to an understanding of some of the knotty problems which occur in the subject. Since the basic aspects of such problems in a pure sense are also the problems of other research workers in the Institute regardless of department, we feel that our program is most promising.

EDITOR'S NOTE. *The Review, with the help of Dr. Wulff, will be glad to supply Review readers with a reference list of the few articles that have been published on powder metallurgy. Please address requests for this bibliography to The Technology Review.*

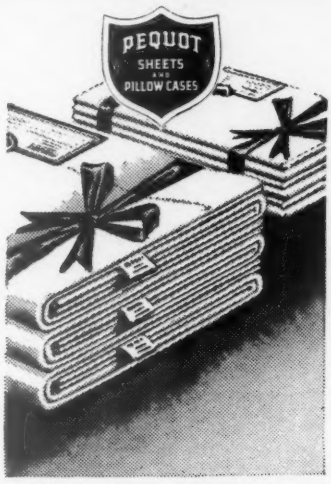
THE TREND OF AFFAIRS

(*Continued from page 69*)

of a degree of 459.69 below zero F., the point at which scientists believe heat ceases to exist in matter and where molecular motion almost stops.

Internal Friction in Metals

THE effect of general strains and of internal structural changes on metals, difficult of detection by most means, appears to be clearly indicated by that mysterious property of metals known as internal friction — a property which causes less energy to be released by the metal than is put into it or, in other words, enables a metal to absorb a portion of that energy. In such processes as the age-hardening of alloys, for example, odd and provocative changes in internal friction occur, among which there appears to be some relationship, though that itself seems often contradictory. Thus, with a certain copper alloy, the amount of internal friction in the metal as quenched goes (*Concluded on page 102*)



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THE TREND OF AFFAIRS

(Concluded from page 101)

through a marked series of changes during an aging period of two hours at 500 degrees C. If then the metal is quenched and cold-worked slightly, its damping capacity jumps back to beyond what it was in the first place.

That this property may have distinct industrial and engineering advantages seems likely. But in the judgment of Professor John T. Norton, '18, of the Institute's Department of Metallurgy, who has been studying the problem for some time, the abstract, or research, aspects of damping must be thoroughly investigated first. The great question in this work is that of establishing a method of accurately measuring internal friction. A reliable method being set up, the position of damping as an indicator of other qualities of the metal can then be studied. Not the amount of damping but damping as a symptom is the center of interest. Its importance rests in the fact that the investigator cannot shrink himself like Alice in Wonderland and thus get inside the metal to see what is going on; a dependable symptomatic diagnosis is therefore of much potential value.

To get at this tool value of damping, Professor Norton has been investigating methods of measurement, synthesizing existing instruments and improving upon them to produce a sensitive, automatically recording torsion pendulum. In this device, the specimen to be tested is used as the elastic suspension of the inertia bar, and the record is taken off by means of a beam of light making a track on photographic paper mounted on a moving drum. The test specimen is locked in place in vertical position between the uprights of the machine, its lower end being held rigidly in the heavy lower portion of the frame. Its upper end is held in the delicately pivoted inertia bar. This bar is drawn out of the plane of the uprights by two magnets and is then released, oscillating as an inverted torsion pendulum with the specimen as the elastic element. Ideally, in the absence of any damping, it would keep on oscillating; actually, of course, the range of oscillation diminishes. The decrement of the oscillation is a measure of the damping capacity of the specimen.

The new machine is an advance in the delicacy of the pivot system holding the inertia bar and differs from earlier instruments of the kind in that, instead of being suspended by a wire in order to prevent transmission of energy to its surroundings, it is mounted on a massive concrete base. Use of the light beam as a means of recording the results eliminates the frictional losses that might be set up by a pencil or stylus attached to the inertia bar and tracing the record directly on paper.

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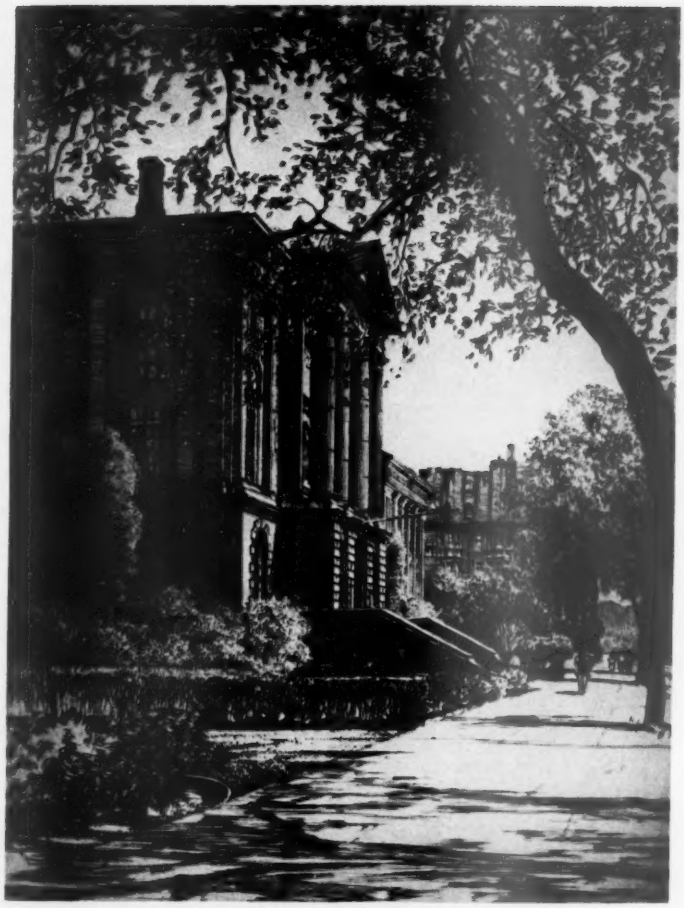

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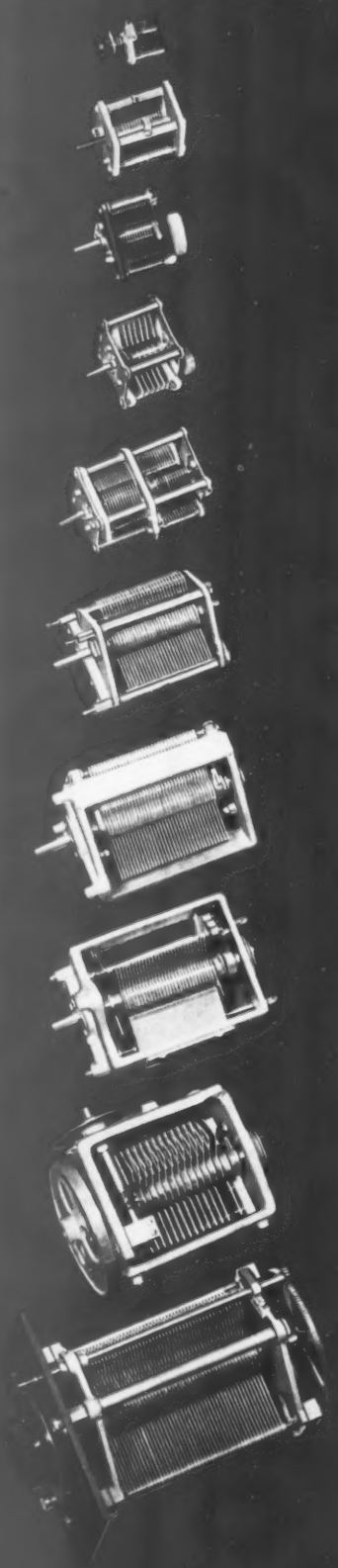

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